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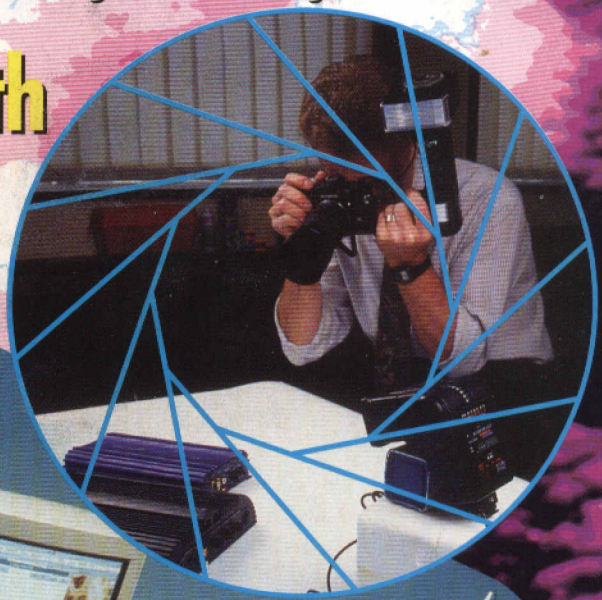

For the Security Conscious—CCD Camera TV Modulator Project

Read all about the emerging technology called Microscopy

Build the versatile power supply project—12/24V DC 220V AC Inverter

Apple EXPO Show Review

Get the Beep!

Pager Competition

see page 72 for full details

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VOL 15. No. 98

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PROJECTS *FOR YOU TO BUILD!*

CCD CAMERA TV MODULATOR 4
This handy project enables conversion of the composite video output from CCD cameras or other sources into a UHF signal, to allow the images to be displayed on a TV set or recorded by a VCR. Can be used as part of an easy to build and inexpensive security camera system for the home or workplace, details of which are provided!

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NEW MICROSCOPY 19
Douglas Clarkson alters the focus to provide enlarged detail about newly emerging technology in ultra-powerful microscopes that operate at an atomic rather than optical level, including the Scanning Tunnel Microscope (STM), capable of sensing the position of atoms by monitoring the tunnelling currents present in the sample.

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Silence please! In the third instalment of this informative series, we pay a visit to that great library of hypertext documents in cyberspace that is the World Wide Web (WWW), blowing the dust off the virtual shelves to peruse the various aspects of the WWW providers, and investigating the possibilities of the many video images, interactive text and sounds available on loan.

PRACTICAL GUIDE TO MODERN DIGITAL ICs 46
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FROM THE EDITOR . . .

Hello and welcome to this month's issue of *Electronics*! We have another bumper packed issue for you to enjoy, with a selection of projects to build, and timely informative features on EMC and the Internet, and of course all our regulars.

Eurostar Competition Winners

We are pleased to announce the result of our fabulous Eurostar Competition.

The top prize of first-class return travel for two on the fabulous eurostar train from London to Paris goes to J. Raymond of South Humberside.

Our two second prizes of two period return tickets on the Eurotunnel Le Shuttle goes to P. Lishman of Cumbria, and L. Everett of East Sussex.

We have not yet heard from the above lucky prize-winners, so if you have not contacted us, please do so as soon as possible.

In the competition we also had six runners-up prizes for the exciting Eurotunnel Exhibition Centre at Folkestone, but we got carried away and drew an extra six, making twelve in all. They were: M. Coultas, N. Kennett, M. Jones, M. Sargent, G. Curtis, C. Ferris, S. Conners, A. Challis, J. Jones, N. Tree, J. Beecham, and E. Cook.

Next month we hope to have photographs of some of the lucky prize-winners enjoying themselves on their days out.

Get the Beep!

Look out for another fantastic competition in this month's issue. You could win one of four pagers in our great give-away. Simply answer the questions on page 72 and return by post to us.

Air Our Views

Just a quick word that the editorial staff are getting queries via Internet addressed to AYV, but in fact they have nothing to do with the Magazine at all. However, we have a fully-staffed Customer Technical Services Department, and queries can be addressed to them. If you are in any doubt please read the information on this page regarding Technical Enquiries and Readers' Letters.

Apologies

To those who are eagerly awaiting the Electronic Volume Pedal and Part 2 of our GPS Development System, we would like to apologise that these have been postponed until a later issue.

So until next month, from the rest of the *Electronics* team and myself, enjoy this issue.

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Project Ratings

Projects presented in this issue are rated on a 1 to 5 for ease or difficulty of construction to help you decide whether it is within your construction capabilities before you undertake the project. The ratings are as follows:

1. Simple to build and understand and suitable for absolute beginners. Basic of tools required (e.g., soldering iron, side cutters, pliers, wire strippers and screwdriver). Test gear not required and no setting-up needed.
2. Easy to build, but not suitable for absolute beginners. Some test gear (e.g., multimeter) may be required, and may also need setting-up or testing.
3. Average. Some skill in construction or more extensive setting-up required.
4. Advanced. Fairly high level of skill in construction, specialised test gear or setting-up may be required.
5. Complex. High level of skill in construction, specialised test gear may be required. Construction may involve complex wiring. Recommended for skilled constructors only.

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Write your order on the form printed in this issue and send it to Maplin Electronics, P.O. Box 3, Rayleigh, Essex. SS6 8LR. Payment can be made using Cheque, Postal Order, or Credit Card.

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If you have a technical enquiry relating to Maplin projects, components and products featured in *Electronics*, the Customer Technical Services Department may be able to help. You can obtain help in several ways; over the phone, Tel: (01702) 556001 between 9.00am and 5.30pm Monday to Friday, except public holidays; by sending a facsimile, Fax: (01702) 553935; or by writing to: Customer Technical Services, Maplin Electronics plc., P.O. Box 3, Rayleigh, Essex, SS6 8LR. Don't forget to include a stamped self-addressed envelope if you want a written reply! Customer Technical Services are unable to answer enquiries relating to third-party products or components which are not stocked by Maplin.

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If you get completely stuck with your project and you are unable to get it working, take advantage of the Maplin 'Get You Working' Service. This service is available for all Maplin kits and projects with the exception of: 'Data Files'; projects not built on Maplin ready etched PCBs; projects built with the majority of components not supplied by Maplin; Circuit Maker ideas; Mini Circuits or other similar 'building block' and 'application' circuits. To take advantage of the service, return the complete kit to: Returns Department, Maplin Electronics plc., P.O. Box 3, Rayleigh, Essex, SS6 8LR. Enclose a cheque or Postal Order based on the price of the kit as shown in the table below (minimum £17). If the fault is due to any error on our part, the project will be repaired free of charge. If the fault is due to any error on your part, you will be charged the standard servicing cost plus parts.

Kit Retail Price	Standard Servicing Cost
up to £24.99	£17.00
£25.00 to £39.99	£24.00
£40.00 to £59.99	£30.00
£60.00 to £79.99	£40.00
£80.00 to £99.99	£50.00
£100.00 to £149.99	£60.00
Over £150.00	£60.00 minimum

Readers' Letters

We very much regret that the editorial team are unable to answer technical queries of any kind, however, we are very pleased to receive your comments about *Electronics* and suggestions for projects, features, series, etc. Due to the sheer volume of letters received, we are unfortunately unable to reply to every letter, however, every letter is read – your time and opinion is greatly appreciated. Letters of particular interest and significance may be published at the Editors discretion. Any correspondence not intended for publication must be clearly marked as such.

Write to: The Editor, *Electronics – The Maplin Magazine*, P.O. Box 3, Rayleigh, Essex, SS6 8LR, or send an e-mail to AYV@maplin.demon.co.uk

TECHNOLOGY WATCH!

with Keith Brindley

Apple, IBM and Motorola have recently announced finalisation of the PowerPC platform specification, called the PowerPC Microprocessor Common Hardware Reference Platform – CHRP (pronounced 'chirp') for short. This culminates the work done by the three companies over the last few years to standardise on a RISC-based computer platform which provides a viable and positive alternative to the CISC-based platform currently used by 90% of computers worldwide. CISC (complex instruction set computing) computers are the norm at the moment, but it's expected by the PowerPC group that RISC (reduced instruction set computing) computers will be needed to cope with the work demanded of computers over the coming years.

It is not the fact that CISC-based computers have serious long-term performance limitations compared with RISC-based computers which is important to the everyday computer user. It is the simple fact that the CHRP platform allows the user to choose which operating system to run; whether it is AIX (IBM's version of the UNIX operating system), OS/2 (IBM's own operating system), MacOS (Apple's Macintosh operating system), or Windows NT (Microsoft's operating system). All will run on a single computer complying to the standard. So, from a common hardware base, a company's whole needs can be met from the most economical computer supplier. With all previous computer generations, the choice of computer defines which operating system the user has to run, which is a significant limitation of freedom.

Interestingly, CISC-based computers will continue to have that limitation, so while Pentium-based computers can use Windows and, er, Windows, PowerPC-based computers built to the CHRP specification will be able to break the Windows (pun intended) barrier. Even more interestingly, CISC-based computers using the 8086-based hardware platform (of which the Pentium is merely the latest) became so popular because they were compatible with IBM's own architecture. Very often, people wouldn't buy a computer unless it was IBM-compatible. With CHRP, however, being IBM-compatible means RISC-based computing using the PowerPC – not a Pentium in sight.

ROM Good Turn

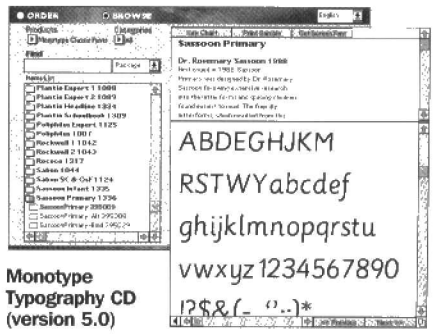
You will know, if you are a regular *Electronics* reader, that I am a firm advocate of computers and new technology. I love them and everything to do with them. What is more, I love anything which makes computers even better and more gadget-ridden. One of the latest gadgets on the computer desktop is CD-ROM. I cannot say this is a spectacular addition if all you do is play computer games all day – the medium is too slow for any real interactive play, but it is a good medium for computer-based encyclopedias and the like. Further, it is an exceptional medium for manufacturers to sell software on.

You can get quite a lot of software these days in CD-ROM form. Most of the large applications in general computing terms, such as office-type combinations, desktop publishing, and graphics illustration programs are available on CD-ROM. It is a successful way to get the large files required to the customer in a way which is speedy and accurate – well, speedier and more accurate than floppy disks, anyway. A by-product of this is the fact that CD-ROM can hold software which might not be used by a customer. A sort of living catalogue. Users can browse through the applications on a CD-ROM, looking at demonstrations if they want, before deciding what to buy, and indeed, whether to buy. In fact, in all but a few cases, software held on some CD-ROMs will not be used at all by a customer.

Such CD-ROMs work because the software held on them can be locked, and only unlocked by keying in a special unlocking code. Of course, the unlocking code is only given to the customer once the product is paid for, usually by credit card over the telephone. CD-ROMs like this work best when they contain software which is fairly specialised. In this way, the producers of the CD-ROM can target prospective customers. So, customers who use office software could be targeted with a CD-ROM containing locked software offering labelling help, envelope addressing utilities, postcode generation, accounting spreadsheets, and so on.

A recent CD-ROM of this ilk is Monotype Typography's CD 5.0. Monotype is one of the world's oldest font creation companies, stemming from hot-metal composing machines for the publishing industry dating back to 1897. This particular CD-ROM contains over 4,000 fonts and related utilities. As you might expect, it is intended mainly for the computer-based desktop publishing market, although just about any computer user could find the need for a new font occasionally. After installing the CD-ROM, you can look at the fonts and programs it contains, before even getting your credit card out of your wallet.

The beauty about the CD-ROM locked software concept is the speed with which a customer has the product available. After 'phoning or faxing an order through, the unlocking code arrives rapidly (within the hour in this particular case), then the software can be installed straight onto the computer.



Monotype Typography CD (version 5.0)

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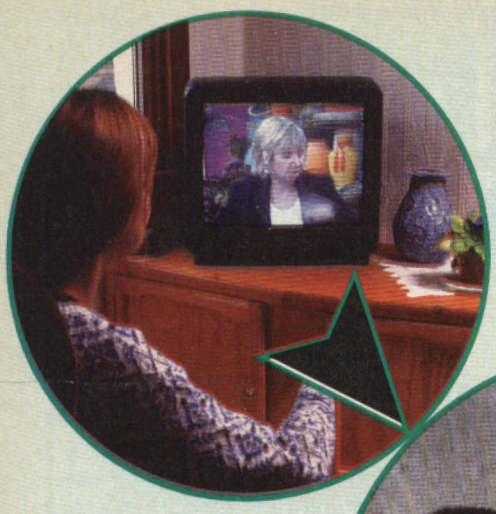
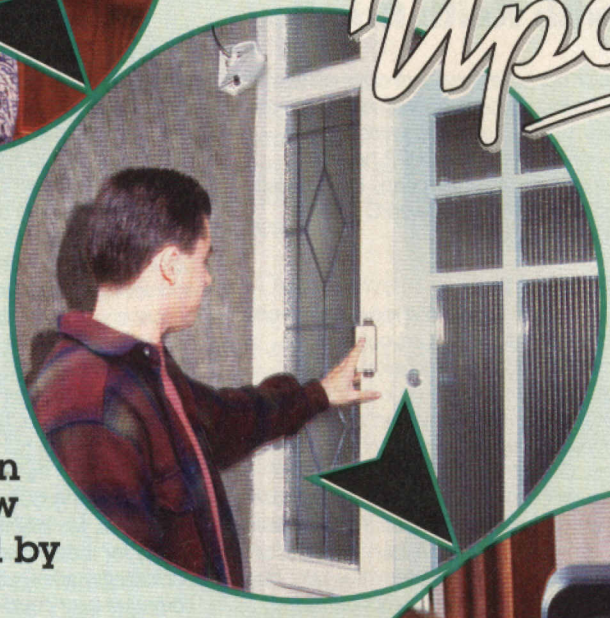
LIFE WITH MICRO CHIP...
SAL
Do you have a pocket dictionary
Why don't you buy an Encyclopedia it will only cost £59.99 on CD ROM
I don't have a CD ROM!
We can sell you this great new multimedia computer £1299-50 - really good
Who do I make the cheque payable to?
Oh C. ASH please

CCD Camera TV Modulator Update





1 PROJECT RATING

This update of the CCD Camera TV Modulator article that originally appeared in *Electronics*, March 1994 Issue No. 75, describes the new design of UHF modulator that was developed as a result of the introduction of improved, smaller versions of the CCD Camera Modules.

Original design by Chris Barlow

Re-engineered by Nigel Skeels

Revised text by Maurice Hunt

KIT AVAILABLE (95020) PRICE £13.99

APPLICATIONS

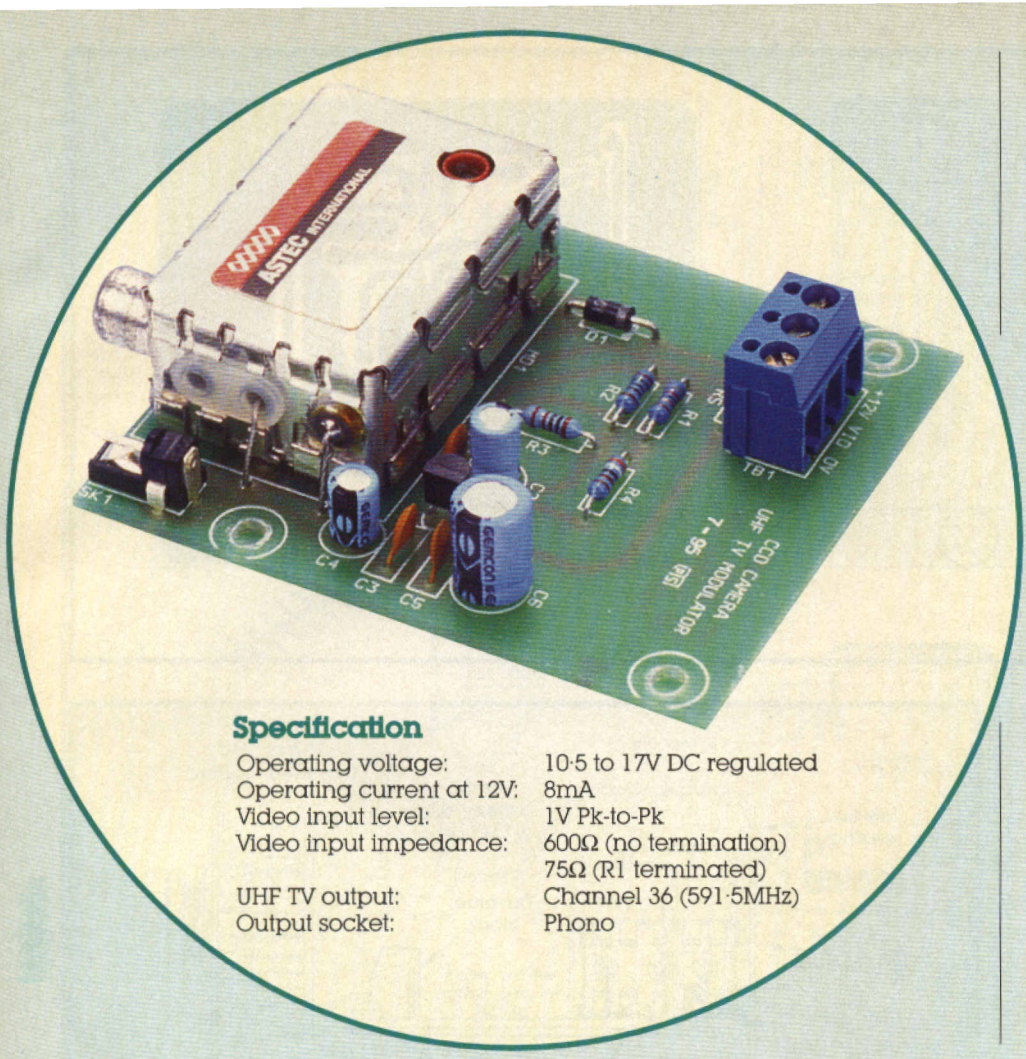
- ★ Run colour and monochrome CCD cameras on domestic TV sets
- ★ Interface video only devices to TV sets
- ★ CCTV Security systems

FEATURES

- ★ Amplification of upper video frequencies
- ★ Low cost
- ★ Built-in supply regulation
- ★ Reverse polarity protection
- ★ Simple construction

Please note that the CCD Camera and housing are not included in the kit.

READY ASSEMBLED (95055) PRICE £149.99 H1



Specification

Operating voltage:	10·5 to 17V DC regulated
Operating current at 12V:	8mA
Video input level:	1V Pk-to-Pk
Video input impedance:	600Ω (no termination)
	75Ω (R1 terminated)
UHF TV output:	Channel 36 (591·5MHz)
Output socket:	Phono

is required, which superimposes (modulates) the video signals from the CCD camera, or a wide range of other units giving a composite video output, onto a high-frequency (UHF) carrier wave. To simplify the construction and alignment of the project, a pretuned modulator module (UM1233) has been employed in the design. The RF output from this modulator is suitable for connection to the aerial input of UK UHF TV sets via a standard coaxial aerial lead.

Circuit Description

Refer to the Modulator block and circuit diagrams, shown in Figures 1 and 2, respectively. These should assist you when following the circuit description or during fault-finding of the completed unit, should this be necessary.

The regulated DC power is applied to the Modulator via the jack socket SK1. This supply must be within the range of 10·5 to 17V DC (regulated), since this also feeds the CCD camera module itself, which is an expensive item to replace should excessive voltage be applied – so do not exceed the maximum voltage!. To prevent reverse polarity damage, diode D1 is included.

The main supply rail decoupling is provided by C6 with additional high-frequency decoupling provided by a 100nF ceramic capacitor C5.

THE CCD Camera TV Modulator has now been redesigned to fit into the purpose-built Security Camera Housing (AG00A), and also to enable a reduction in the wiring necessary to create a security camera system. As such, a new PCB is used, along with a rearranged layout and the use of a power socket and terminal block in place of the PCB pins used previously.

The video output from the Maplin monochrome and colour CCD camera modules (AY16S and AR59P, respectively) cannot be connected directly to the majority of domestic TV sets, since their output signal is in composite video form. Some TVs do have a direct video input socket (Peritel), also known as a SCART socket, to which the camera can be directly connected, but most only have a UHF aerial input socket for the reception of TV stations. To solve this problem, a low-cost UHF modulator

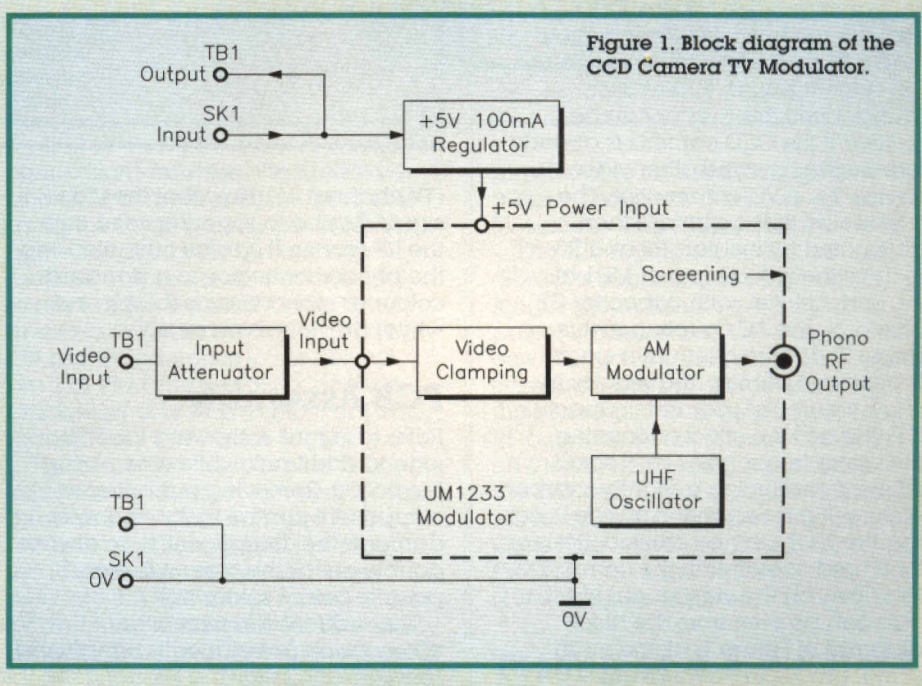


Figure 1. Block diagram of the CCD Camera TV Modulator.

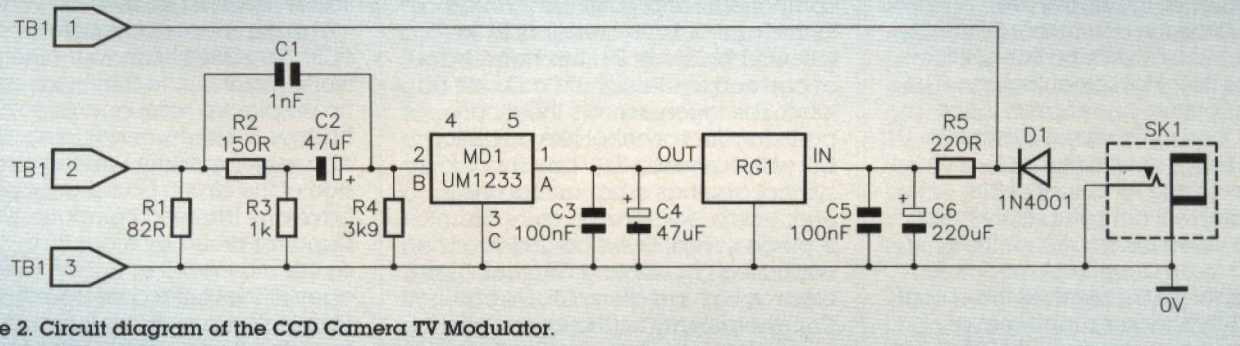
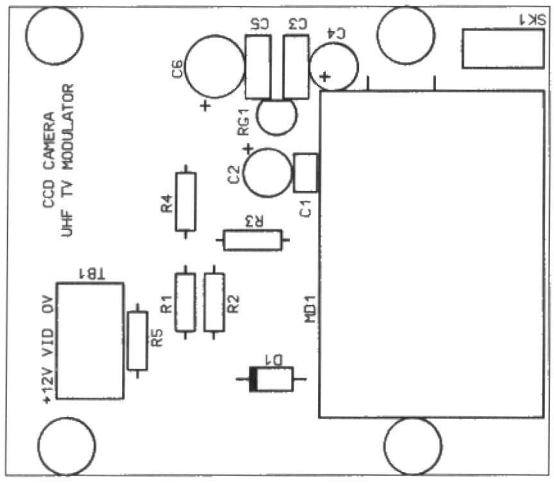


Figure 2. Circuit diagram of the CCD Camera TV Modulator.



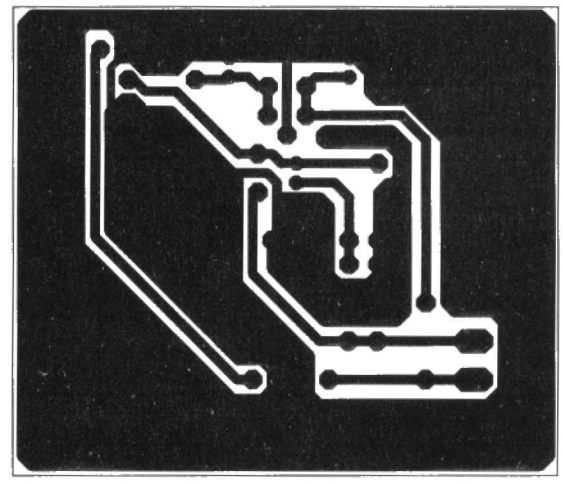


Figure 3. PCB legend and track.

The modulator, MD1, requires a +5V stabilised supply. This voltage is obtained by using a small 100mA regulator, RG1, with capacitors C3 and C4 providing the final decoupling to the power input of MD1.

The video signal from the CCD camera is applied to pin 2 of the three-way terminal block TB1, and the ground connection is made to pin 3. The input impedance of the UM1233 modulator, MD1, is significantly higher than the 75Ω termination resistance required by the CCD camera modules. This termination load is corrected by placing across the video input an 82Ω resistor, R1. However, this resistor can be omitted if the CCD camera is already terminated by some other video device, i.e. a VCR or monitor. The terminated video signal is then attenuated by resistors R2 and R3 to drive the video input of MD1 at the correct level, with capacitor C2 providing the AC coupling to this stage. The video attenuator stage is bypassed at high frequencies by a low value (1nF) ceramic capacitor, C1. This has the effect of boosting the upper frequencies by a small amount, producing a slightly sharper picture. If this enhanced image is not required, C1 may be omitted. Resistor R4 is used to maintain the correct DC bias level on the video input of MD1.

As can be seen from the block diagram of Figure 1, all the main signal processing circuits are contained within the UHF modulator block MD1. All the stages are powered from a common +5V supply, RG1, with the 0V ground connection made to its metal screening can. The incoming video information is first passed through a signal clamping circuit. This is to ensure that if overdriven, the RF output of the modulator will not completely break up. The video information is then applied to an amplitude modulator (AM) stage, which receives the output from a RF oscillator running at a frequency of approximately 591·5MHz

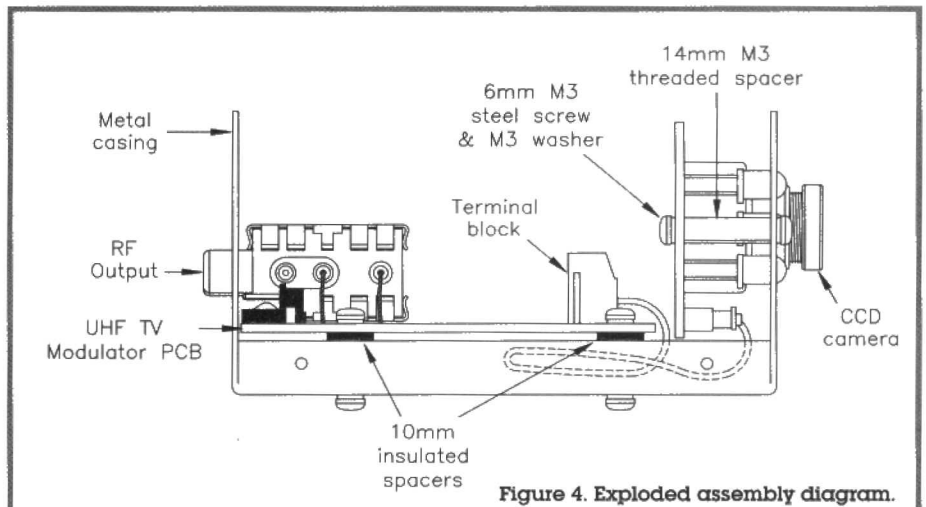


Figure 4. Exploded assembly diagram.

(TV channel 36). Now that the video signal has been superimposed onto the RF carrier, it can be outputted, via the phono connector, to a standard colour or monochrome (black and white) UHF television receiver.

PCB Assembly

Refer to Figure 3, showing the PCB legend and track while assembling the board. Removing a misplaced component can be tricky and may damage the component(s), so always double-check the type, value and polarity before soldering!

The sequence in which the components are placed is not critical. However, the following sequence is advised. Commence with the smaller components and progress through to the largest. Install resistors R1 to R5, followed by diode D1; this has a band at one end to identify the cathode (K) lead. The legend shows the diode position with a symbol like a resistor, but with the prefix 'D1', and this symbol also has a bar across one end, which is where the cathode is placed. Next, fit the ceramic capacitors (C1, C3 and C5) and electrolytic capacitors (C2, C4 and C6). The polarity for the electrolytic capacitors is indicated by a plus sign (+) on the PCB legend. However, the majority of electrolytic capacitors have the polarity designated by a negative symbol (–), in which case, the lead nearest this symbol goes in the hole *opposite* to the positively designated hole.

Next, install the voltage regulator RG1, making sure that its flat surface conforms to the package outline on the legend, followed by the power socket SK1 and terminal block TB1, with the access holes facing outward. The next stage is to mount the UM1233 modulator MD1, making certain that the two wire connections are in their correct positions to align with the holes in the PCB. To secure MD1 to the board, simply bend down the two fixing tags through 90°, and solder them in place.

This completes the assembly of the PCB. Carefully check your assembly work, making sure that there are no misplaced components, solder bridges, whiskers or dry joints. It is also very important that the solder side of the circuit board does not have any trimmed component leads standing proud by more than 3mm, as this may result in a short circuit against the metal camera housing. Finally, remove excess flux from the board using a suitable solvent.

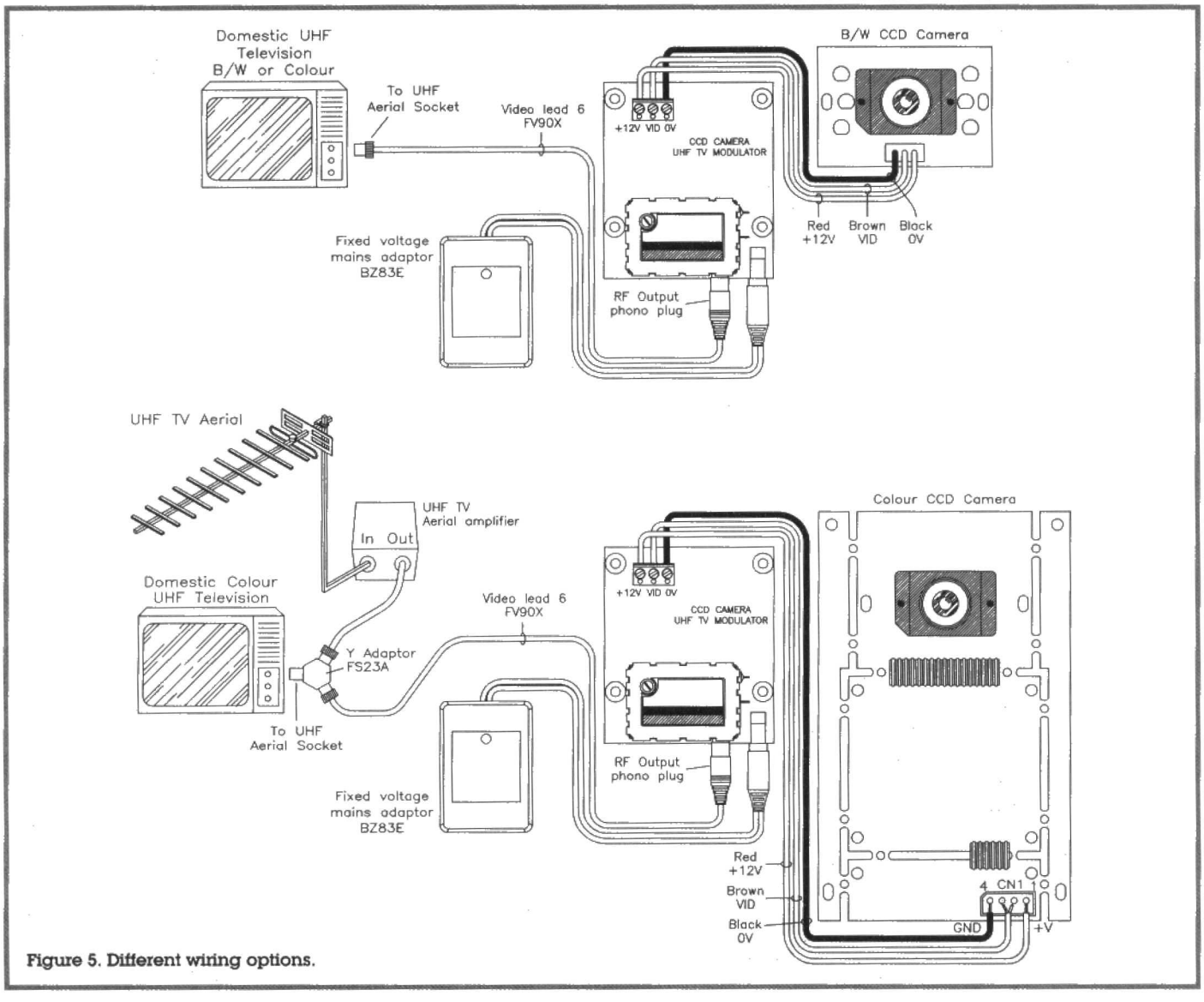


Figure 5. Different wiring options.

Security Camera Housing Assembly

The specified CCD Camera Housing (AG00A) is supplied predrilled to accept the camera module, and the Modulator board has been designed to fit the other existing holes in the housing. All that remains is for the boards to be fixed into place by means of screws, washers and spacers, some of which are provided with the housing. However, additional spacers and screws will be required – refer to the Optional Parts List and to the assembly layout diagram shown in Figure 4 for details.

Note that some items of hardware supplied with the housing are not used, in particular, the hexagonal plastic spacers and some of the self-tapping screws, since not all of these are needed. Take care not to overtighten the screws, so as to avoid damaging the PCBs. The infra-red LEDs' legs may need to be manipulated slightly to allocate all six LEDs to their respective holes in the housing.

Wiring

As can be seen from Figure 4, the total amount of wiring has been kept to a minimum – just three wires. The connections between the Modulator and CCD camera module are made using the three-way length of ribbon cable supplied with the camera module. The red lead is connected to pin 1 of the terminal block TB1 (marked +12V on the PCB legend), the brown lead goes to the central pin 2 of TB1 (marked 'VID'), and the black lead connects to pin 3 of TB1, marked 0V – see Figure 5.

There are two basic methods of using the modulator with your TV set, these being shown in Figure 5. The first and most simple is to just plug the RF output from the modulator lead into the UHF aerial socket on your TV and tune to channel 36. The only drawback to this is that since you no longer have your TV aerial connected to the set, no UHF TV stations can be received. In the second method, a coaxial Y-adaptor is used to combine the UHF signals from the modulator and TV aerial, thus allowing both to be tuned in. However, to prevent any stray signals from the modulator reaching your TV aerial and being possibly picked up by the next door neighbour, you should use an indoor aerial amplifier. This will have two beneficial effects, blocking the signal from the modulator to the aerial and compensating for the insertion loss of the Y-adaptor. Remember that you may have to retune the modulator to a clear channel if it clashes with any TV stations or a VCR/satellite receiver.

The 12V regulated AC-DC adaptor (BZ83E) is supplied with a generous length (approximately 1·83m/6ft) of power cable and six universal plugs, one of which fits the socket SK1. Take care to ensure the correct polarity – the centre pin must be positive. The RF output from the Phono connector on the UM1233 modulator is fed to the UHF aerial socket of your television via a ready-made Phono Plug to Coax Plug Video Lead, such as FV90X (1·2m long), or JW40T (10m long), as required.

Testing and Alignment

Referring to the wiring diagram of Figure 5, connect an appropriate 12V regulated adaptor (such as BZ83E) or power supply via the socket SK1, and connect the RF from the modulator MD1 to a colour or monochrome (B/W) TV set tuned to UHF channel 36, and the TV should display the image seen by the CCD camera. If no picture is visible, try adjusting the channel tuning control on the television.

The frequency output of the video modulator MD1 is factory set to channel 36 (591·5MHz), which should be suitable for most applications.

If necessary (and having rechecked your assembly work/connections/TV settings beforehand), it can be retuned by adjusting the ferrite core of its oscillator stage. As the modulator has no 6MHz FM sound subcarrier, the volume control on your TV should be set to minimum, otherwise all you will hear is a hissing sound.

Using the Modulator

When wiring up and installing a video camera system, it is recommended that the connections between the power supply, modulator and CCD camera are kept to the minimum length possible, to minimise the possibility of interference. If the camera system is to be used at any greater distance from the television, then the RF output lead from the modulator should be extended by using a coaxial line socket (YW09K), low-loss coaxial cable (XR29G/XR87U) and a coaxial plug (HH07H).

Figure 6 shows a typical installation of a security camera system (to monitor callers at your door). The camera should be mounted high up and preferably out of sight, to protect it from vandalism or theft, and it must be suitably protected from the elements, as the specified housing is not waterproof. Note also that the housing is really only suitable for the monochrome CCD camera (which is the ideal choice in any case for a security camera, since it can 'see' in the dark). This is due to the extra holes drilled for the infra-red LEDs, and because this housing is not large enough to contain both a colour CCD camera (which is larger than the monochrome version) and the modulator.

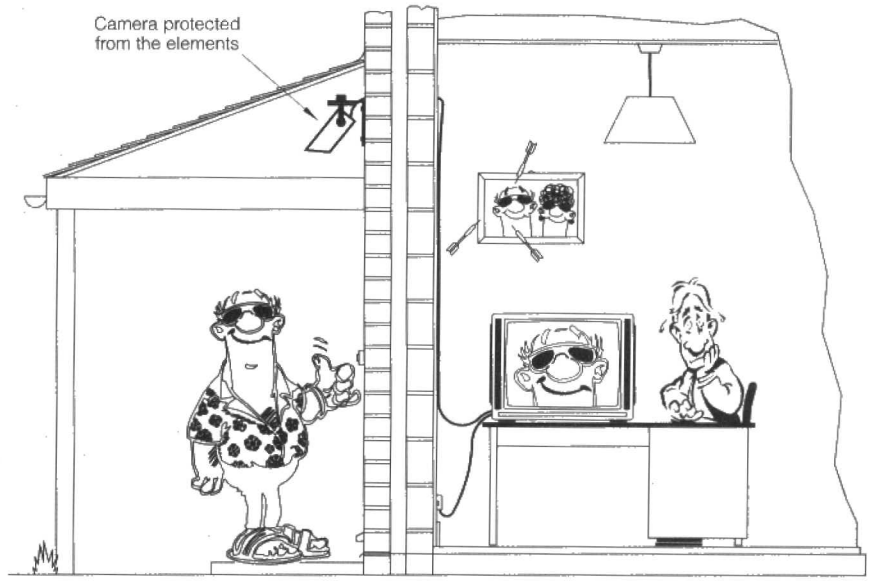
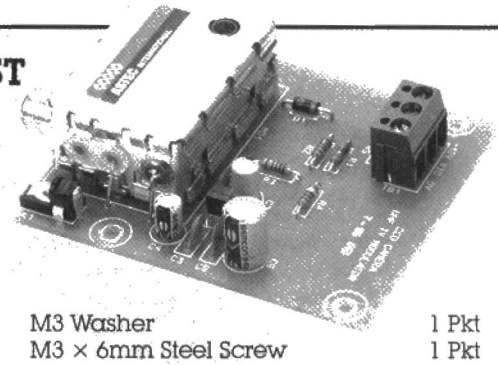


Figure 6. Typical installation.

Ensure that all cables are protected where they pass through holes in walls, using strain relief sleeving/grommets (e.g., JX64U-JX66W, or JX71N), to prevent the risk of short-circuiting due to cable damage. Plastic cable clips, such as BH21X/RT63T (5mm diameter) or 'P' clips (e.g., LR44X) can be used to neatly secure lengths of coaxial cable to walls, door frames, etc.

Obviously, when setting up the security camera system, ensure that the cables are well hidden from view or made inaccessible, to avoid them being 'got at' by unscrupulous individuals!

CCD CAMERA TV MODULATOR PARTS LIST



RESISTORS: All 0·6W 1% Metal Film			
R1	82Ω	1	(M82R)
R2	150Ω	1	(M150R)
R3	1k	1	(M1K)
R4	3k9	1	(M3K9)
R5	220Ω	1	(M220R)
CAPACITORS			
C1	1nF Metallised Ceramic	1	(WX68Y)
C2,4	47µF 16V Sub-miniature Radial Electrolytic	2	(YY37S)
C3,5	100nF 16V Miniature Disc Ceramic	2	(YR75S)
C6	220µF 16V Radial Electrolytic	1	(FF13P)
SEMICONDUCTORS			
D1	1N4001	1	(QL73Q)
RG1	LM78L05ACZ	1	(QL26D)
MISCELLANEOUS			
MD1	UHF Modulator UM1233	1	(FT30H)
	Phono Plug to Coax Plug Video Lead	1	(FV90X)
	PCB Mounting Miniature DC Power Socket	1	(FK07H)
	3-way PCB Mounting 5mm Terminal Block Type 300	1	(JY94C)
	PCB	1	(95017)
	Instruction Leaflet	1	(XU55K)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
	Regulated 12V Mains Adaptor	1	(BZ83E)
	Monochrome CCD Video Camera	1	(95052)
	Colour CCD Camera (see text)	1	(95053)
	M3 × 10mm Insulated Spacer	1 Pkt	(FS36P)
	M3 × 20mm Threaded Insulated Spacer	1 Pkt	(FG38R)
	M3 Washer	1 Pkt	(BF62S)
	M3 × 6mm Steel Screw	1 Pkt	(JY21X)
	Two into One Coaxial Y-Adaptor	1	(FS23A)
	10m Coaxial Flylead	1	(JW40T)
	Coaxial Connector	1	(HH11M)
	Security Camera Housing	1	(95054)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.

Order As 95020 (CCD Camera TV Modulator) Price £13.99

The following new item (which is included in the kit) is also available separately, but is not shown in the 1996 Maplin Catalogue.

CCD Camera TV Modulator PCB
Order As 95017 Price £2.99

The following Optional items are not included in the kit, but are available separately.

Monochrome CCD Camera **Order As 95052 Price £119.99**F1
Colour CCD Camera **Order As 95053 Price £249.99**H1
Security Camera Housing **Order As 95054 Price £21.99**A1
Ready Assembled CCD Security Camera
Order As 95055 Price £149.99H1

SOCIAL COMPUTING

by Frank Booty

Social computing is a paradigm that will utilise computing to improve communications between people and organisations. It will comprise a new generation of telephones, TVs and PC 'mutants' that access on-line services through a variety of networks. US consulting company, Forrester Research, forecasts that large organisations will use social computing to build new connections to customers. Those who do not address the emergence of this powerful new communications channel are expected to suffer in the market-place.

It is always difficult to predict accurately; but if transported to the year 1999, how many could guess what a company might look like? It is expected to barely resemble today's organisation. Within five years, a barrage of new technologies will radically change the relationships with customers, product features and service delivery and the structure of manufacturing, sales, service and distribution.

But what could force this upheaval? Over the past year, computer hardware manufacturers, software providers, cable TV companies, telephone companies and other utilities have been having frenzied discussions, and making deals. It is thought that three strands of innovation are set to appear from this fog of seemingly disconnected activity:

- A new generation of telephones, TVs and hand-held electronic devices (see Figure 1). By the end of the century, all of these products will support two-way communications and a richer content.
- Wireless and traditional networks. Accelerated wireless development will mesh with enhancements to the existing 'pipes' of the telephone, cable TV and private company data networks (thus enabling 'anywhere, anytime' communications).
- An explosion of information services (e.g. CompuServe) – there has already been a lot of press coverage of the Internet, with its 25 million users worldwide shunting e-mail messages all over the place.

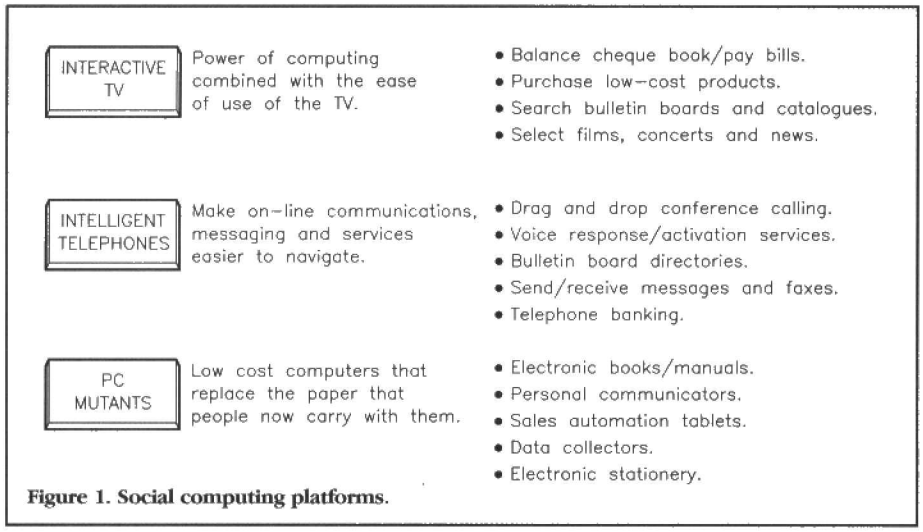

INTERACTIVE TV
Power of computing combined with the ease of use of the TV.
• Balance cheque book/pay bills.
• Purchase low-cost products.
• Search bulletin boards and catalogues.
• Select films, concerts and news.
INTELLIGENT TELEPHONES
Make on-line communications, messaging and services easier to navigate.
• Drag and drop conference calling.
• Voice response/activation services.
• Bulletin board directories.
• Send/receive messages and faxes.
• Telephone banking.
PC MUTANTS
Low cost computers that replace the paper that people now carry with them.
• Electronic books/manuals.
• Personal communicators.
• Sales automation tablets.
• Data collectors.
• Electronic stationery.

Figure 1. Social computing platforms.

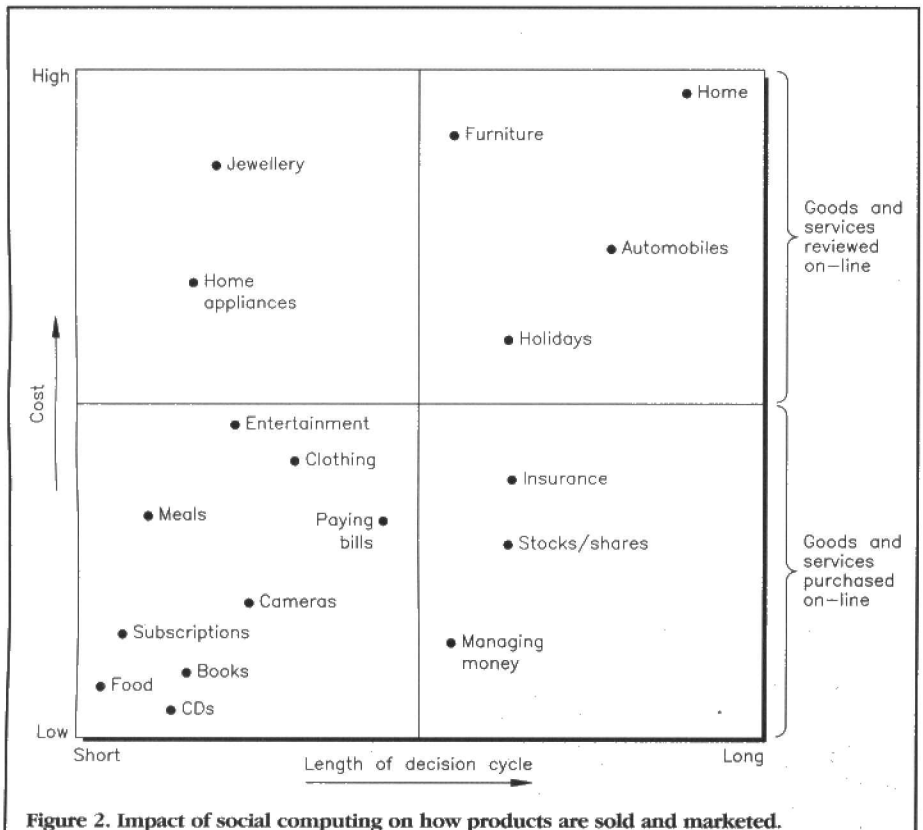


Figure 2. Impact of social computing on how products are sold and marketed.

In the US (where else), Forrester Research has been actively looking at the emerging phenomenon of 'social computing'. Companies and concerns trying to come to terms with the wave of innovation include Apple, AT&T, Citicorp, Compaq, Ericsson, Intel, Microsoft, Motorola, Newsweek, Sony, United Parcel Service and Xircom.

Social computing can be summed up as technologies that create new ways for people and organisations to communicate. The architecture is expected to harness computing to improve social interaction. Social computing will extend into the hands of ordinary consumers as well as business, with the net result that people will converse more broadly, new electronic communities will be created, and text, pictures and sounds will be woven into conversations.

By changing the way people communicate with each other and with companies, social computing will shake the foundations of business. Traditional notions of buying and selling will change as the new paradigm lets customers order products and services through several electronic media, review and compare richly-textured product information, and communicate extensively with other consumers and businesses.

Forrester's work has evinced the fact that the extension of computing into customers' hands will force the top companies to change the way they do business. The new technologies will be applied within the corporation. However, it will be the increasing ability of ordinary people to communicate electronically with large corporations that will really change factors competitively. Companies that fail to see the new possibilities will see their market share usurped by more forward-thinking competitors. Although the impact of social computing varies across industries (refer to Figure 2), its effects will be far reaching, outlined as follows:

- **Consumer Products.** People will order low-cost items (books, compact disks and clothing) through on-line services available

via intelligent telephones and interactive TV. While people will not buy cars over the telephone, firms selling high price items cannot afford to ignore the new medium, as enriched product information services will be required to assist customers make shopping easier.

- **Service Industries.** Electronic banking will be supported on all social computing platforms. Airlines, hotels and restaurants will be impacted by business executives equipped with PC mutants.
- **Retail and Distribution.** Rather than be eclipsed by customers buying directly from the manufacturer, retailers with their own social computing strategy will become 'one-stop electronic shops'. They will be able to steal a march on producers by selling goods from many companies, as well as offering personalised electronic shopping and delivery services.
- **Businesses that Work with Other Businesses.** Mutant-based messaging will create electronic relationships between partners and suppliers that will yield a competitive advantage (more efficient communications means more productive joint development).

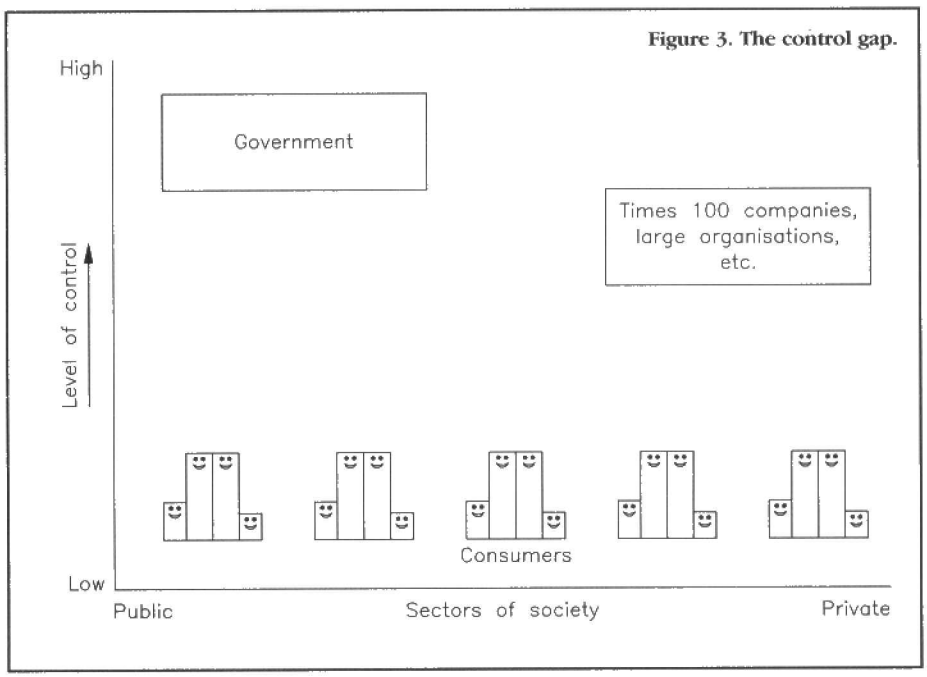
Social computing will not be driven by technology alone, however. The paradigm will emerge only when innovation collides with unmet needs in a society. It is believed that two socioeconomic trends will combine to make the architecture possible:

1. The need to regain control. During the past decade, living a normal life has become increasingly difficult – longer working hours, intense employer productivity expectations and two-wage-earner families mean much reduced leisure time.
2. The arrival of the techno-tuned consumer. Particularly with schoolchildren reared on a diet of PCs and technology, and now entering the workforce, expectations of technology have never been higher. In 1984, PCs, cellular phones and answering machines were cult objects. Today, they are commonplace. So people have a problem and they look to technology to solve it. Social computing is expected to help narrow the control gap, as Figure 3 shows.

To respond to the new customer demands, companies will be forced to change the way they market, sell and support goods and services. The dispersal of computing and networks throughout society will let companies create new information services that respond to people's need to regain control, as shown in Figure 4. Accounts that move quickly can create a new relationship with their customers. Such new customer connections will be based around three points:

1. Putting the consumer's schedule first when it comes to service. People should no longer have to wait around for service personnel to install cable TV, mend appliances or deliver furniture. Intelligent telephones, combined with store and forward messaging and paging capabilities, will allow for more convenient scheduling of service technicians.
2. Eliminating red tape situations. Aggravating trips to a bank, insurance company or doctor's surgery to pick up and fill out a form can be time wasting. Electronic customer service bulletin boards could be used to provide households access to the appropriate form. The completed version would be returned via universal electronic mail.
3. Making the buying process easier. Companies could use social computing to ensure that finding the appropriate product at a low price, at a nearby location, no longer takes hours of searching.

Figure 3. The control gap.



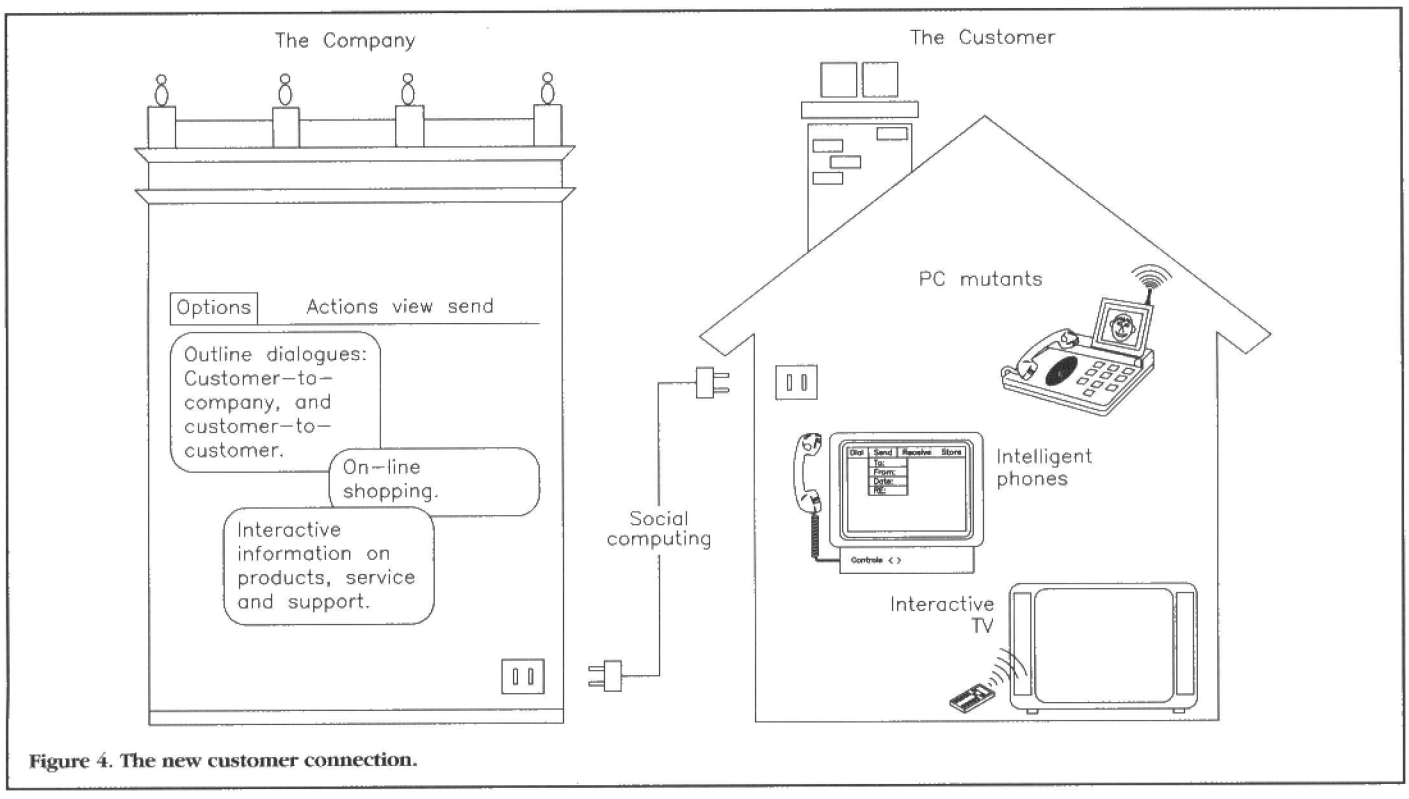


Figure 4. The new customer connection.

Social computing will force the needs of the customer to an unprecedented level. As companies develop a better understanding of consumer needs through the new communications channel, the effects will include:

- The elevation of marketing's role. Social computing will provide companies with information that will enable marketing executives to anticipate and respond to trends in fashion, culture and purchasing behaviour.
- The remaking of product development. With far more customer input, creating products will become a direct response to specified consumer desires, rather than educated guesswork.
- Conflicts among distribution channels. By ordering products directly from the manufacturer, consumers will bypass traditional retailers and distributors. This move will prompt bitter fights over who delivers goods and services, and how. It is expected that companies will completely revamp their approach to distribution, and retailers will become order fulfilment and delivery units, not showrooms.
- A new sales and service infrastructure. Once on-line, customers will demand direct access to support organisations. In response, companies will rethink how they structure their field operations. Instead of maintaining expensive service depots and sales offices, the top companies are expected to opt for software and networking investments that keep mobile workers in front of customers.

Getting Started

The advent of this new computing paradigm will raise three important questions for the leading companies:

1. How quickly will social computing develop?
2. Does it make the move to client-server irrelevant?
3. What role will the management information services (MIS) department play in the new architecture? Taking each question in turn:

1. Social computing will arrive in fits and starts. The architecture will not spring up overnight, fully formed (refer to Figure 5). First, many technology pieces need to fall into place:

- Platforms have started to appear already. PC mutants are the first (e.g., Apple's Newton). Early announcements of intelligent telephones have been made in the US, but are not expected to hit the market until early 1995. Interactive TV (despite what you may read elsewhere) is stuck in a legal and regulatory mire, and nothing can be expected until, say, 1996.
- Networking is in a state of flux. Digital telephony is being applied; cable TV networks are springing up; the analogue network, while being two-way, lacks the performance to transmit complex digital data; ISDN struggles along while ATM waits in the wings as the solution for problems that do not yet exist; and the wireless brigade waits for its marketing window against a backdrop of enhancements to existing cellular infrastructures and new systems designed for PC mutants.
- Services will roll out in phases. Corporate bulletin board services (many constructed around Lotus Notes) will appear first. While these could be built now, large-scale public services will not have access to a mass of customers until the networks are in place.

2. Client-server prepares the way for the coming architecture. People already moving towards client-server should not worry, as many of the procedures and technologies encountered in the migration from mainframes and minicomputers will come in useful in the future:

- Common technologies exist between the two architectures. Lotus Notes, server databases, electronic mail, workflow and mobile networking will support the coming paradigm. By experiencing these offerings in the client-server world, companies will gain valuable development experience for the architecture just round the corner.
- Implementing and supporting broad data access. Client-server brings information to most desktops in organisations. Policies and procedures developed to support the approach to data here will prove useful when computing is extended out to customers.
- Designing applications for ease of use. Writing graphical applications will force companies to examine user interface issues carefully. This is a first step for developing on-line services that ordinary households can easily comprehend.

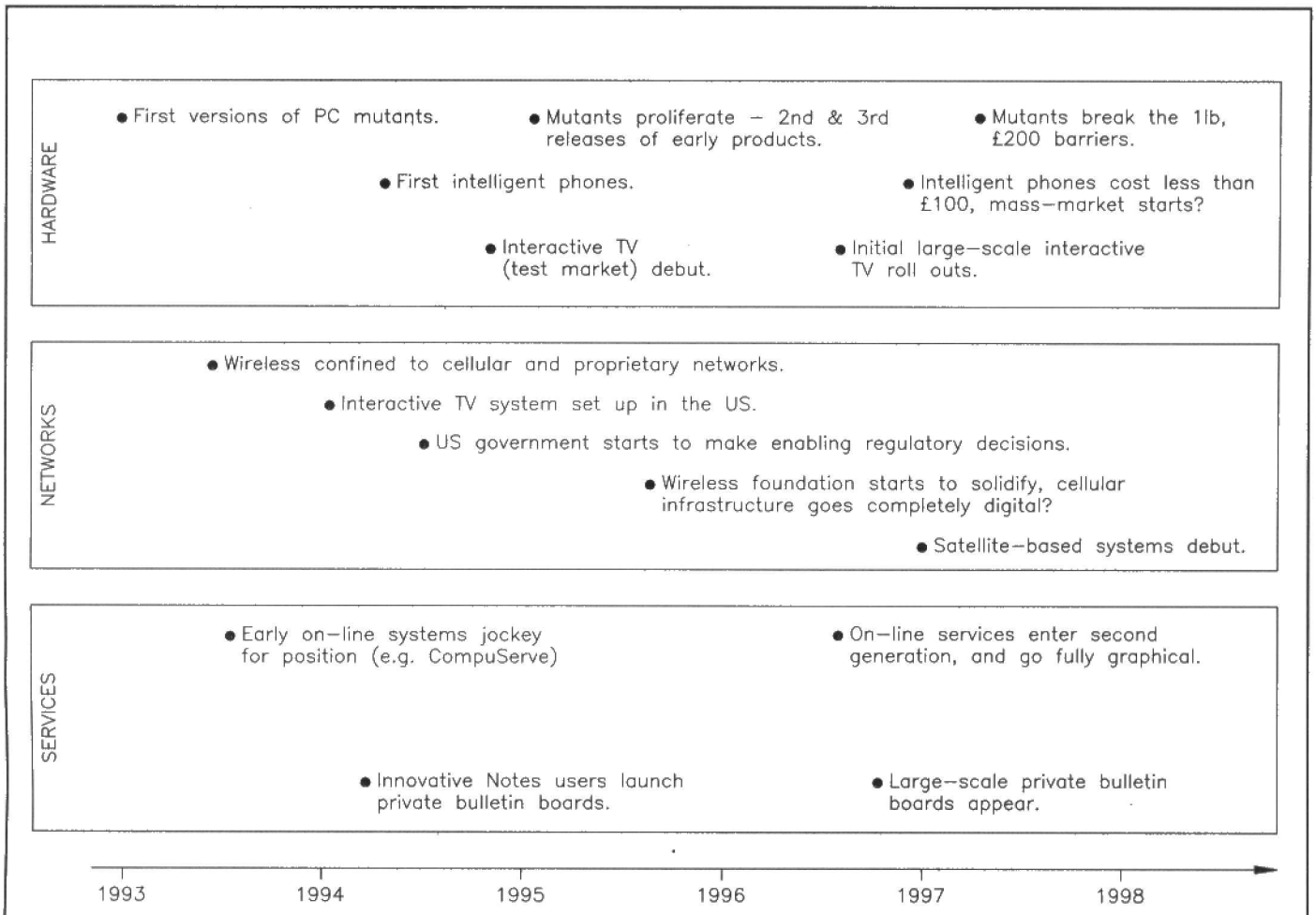
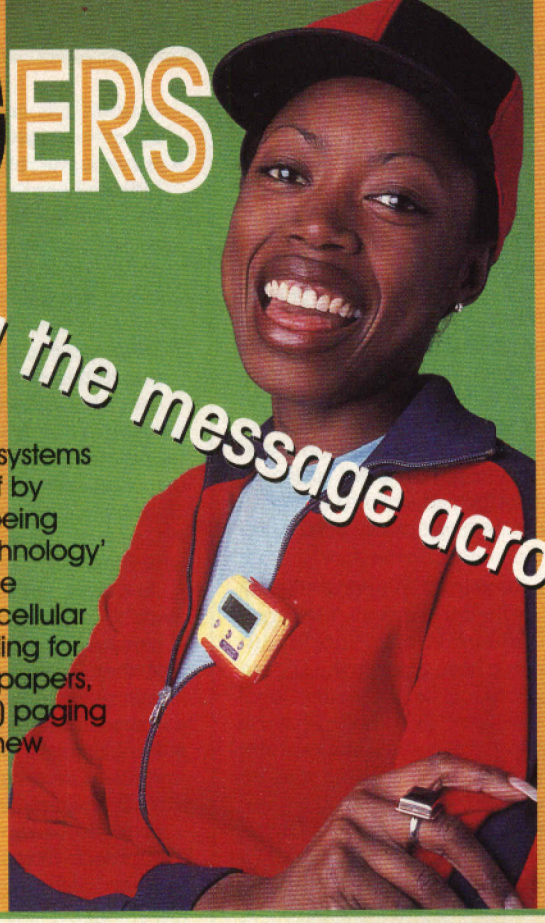

HARDWARE
• First versions of PC mutants.
• Mutants proliferate – 2nd & 3rd releases of early products.
• Mutants break the 1lb, £200 barriers.
• First intelligent phones.
• Intelligent phones cost less than £100, mass-market starts?
• Interactive TV (test market) debut.
• Initial large-scale interactive TV roll outs.
NETWORKS
• Wireless confined to cellular and proprietary networks.
• Interactive TV system set up in the US.
• US government starts to make enabling regulatory decisions.
• Wireless foundation starts to solidify, cellular infrastructure goes completely digital?
• Satellite-based systems debut.
SERVICES
• Early on-line systems jockey for position (e.g. CompuServe)
• On-line services enter second generation, and go fully graphical.
• Innovative Notes users launch private bulletin boards.
• Large-scale private bulletin boards appear.
1993
1994
1995
1996
1997
1998

Figure 5. Social computing: the early years.

Continued on page 13.

PAGERS

Getting the message across!



Despite Paging systems being written off by the pundits as being 'yesterday's technology' (one which in the face of mobile cellular 'phones is heading for its redundancy papers, every few years) paging is now given a new lease of life.

by Alan Simpson

Colourful 'designer' name pager.

BASICALLY, a paging system is a one-way radio system for transmitting data. Originally developed for short-range applications (under one mile), the technology has developed for wide-area networks (WANs). Text books suggest that from the customer's point of view, pagers can fall into three main categories: those which emit a single tone, those which emit a range of tones with each tone signifying a particular predefined message, e.g., ring the office, and those which display an alphanumeric message.

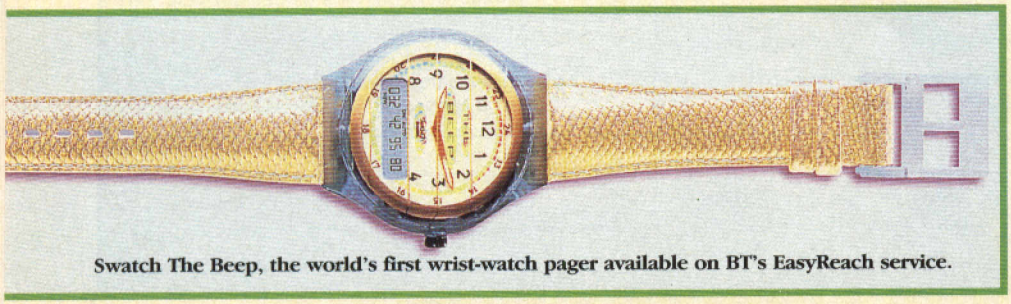
Those text books will now have to be rewritten to incorporate the latest development in the paging world. Stand by for 'Calling Party Pays' paging. Your pager displays a code which you can translate (it could be a 'phone call that you should respond to) or a message such as 777 ('good luck!'), 925 ('I'm at work'), or 121 ('Dinner for two'). The big difference is that once you have purchased your CPP pager, there are no connection charges, rental charges or tariffs to worry about. Calls made to any of these consumer pagers cost just 25p per call. (However, calls from payphones, mobile and non-BT networks are charged at prevailing rates).

In fact, one of the highlights of Live '95 (the others, of course, being the Maplin/*Electronics* Magazine stand and the heavy promotion of Microsoft Windows '95) was the mass arrival of the new breed of personal pagers. In particular, the BT Echo, The Benetton and the Swatch bleeper, which have been bundled under the BT EasyReach logo. Swatch apart, what they also have in common is that they are manufactured by Motorola, who are also responsible for the Mercury MiniCall CPP pager.

Stand By for the Revolution

According to BT Mobile, EasyReach is paving the way for a revolution in consumer communications. "Across Europe, paging has already become the way of life for everybody from teenagers to pensioners to keep in touch. It now looks like Britain will soon be catching up with its fashion-conscious neighbours – thanks to BT. True to form, BT Mobile is leading the way with an amazing selection of innovative numeric paging options which are user-friendly and superb value for money. You can choose from the wild and wacky Benetton, perfect for the dedicated follower of fashion; the Echo, a discreet pager which is most definitely not shaped like traditional models; and stylish Swatch the Beep, the world's first wristwatch pager that stays attached to you!"

Overlooking, perhaps, some of the hype – the Calling Party Pays service in much of Europe including Italy and Spain, is currently banned, mainly in order to protect existing pager subscription services. However, here in the UK, our enlightened carriers have no such reservations – BT and Mercury clearly believe that the colourful designer pagers aimed at youthful users will breathe new life into the pager market-place as a whole. Also, apart from selling pagers in quantity, Motorola's General Manager, Greg Nelson, believes that promotion of the new units will help spread market awareness of the Motorola name. A market-place, incidentally, that Motorola expects to reach a million consumer pagers in use in Europe by the end of 1995.



Swatch The Beep, the world's first wrist-watch pager available on BT's EasyReach service.

Beeping Paging Services get a Boost

The CPP pager should not be seen as a replacement for the more typical subscription-based services, but as a method of generating a new set of (youthful) customers, whilst stimulating product and telephone network revenues. As Greg Nelson puts it, "many consumers (particularly the young) who cannot afford a mobile cellular 'phone, are discouraged from normal paging services by the idea of having to pay a fixed monthly subscription service. Nor for that matter, do they want the tedious routines associated with filling in subscriber and agreement forms at specialist communications shops. Young consumers feel more at home in a normal electronics or electrical store that only involves the purchase of the unit, and they are happy to let the caller to the pager pay the added premium. This attitude is in strict contrast to the average business user, who accepts the payment of a monthly subscription in order to keep in touch with their customer or clients. For them, expecting the caller to pay a surcharge would be unacceptable."

Essentially, the new range of pagers offer a 12-digit display screen for numeric messages of up to 20 digits long with memory for at least eight messages, usually with time stamping. Features include an automatic on/off facility to extend battery life and silent or vibrating alert function. BT Mobile are determined to earn some street credibility points. "EasyReach paging is new, and it's fun. Your friends and family will be able to send you messages wherever you are, simply by pressing keys on their tone-dial 'phone. Within minutes of someone needing you, you'll get the message. It's new. It's fun. It's EasyReach."

Get Connected

So what is on offer, and what do you get for your money? In the EasyReach stable, The Echo has a stylised rounded shape to break

BT's Second-generation Paging (SGP) Network

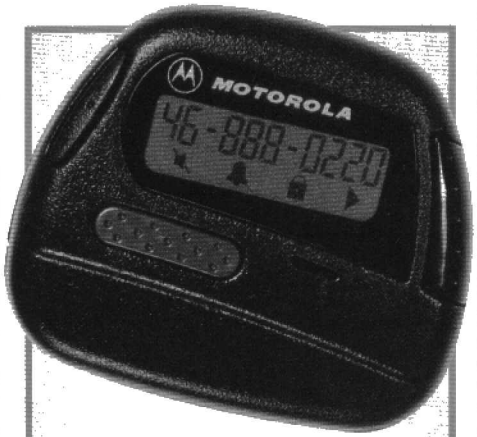
Direct input of numeric message via touchtone phone	→	Paging control equipment (BT)	→	Regional controls (London & Birmingham)	→	Zone transmission controls	→	RF Base stations	→	Transmit message to pager within seconds

the image of pagers as being black boxes. As is the case with all of the EasyReach models, messages can be received almost anywhere in the UK (The coverage map suggests some 98% of the population). Available in a range of colours, the unit comes with a neat lanyard which lets you attach it to a bag or case, or to hang from your belt. When people need you, they simply dial your BT Echo number (like a regular 'phone number), then key in the digits making up the message, to a maximum) of 20 digits. About the size of a match box and weighing in at just 66g including battery, the unit also displays the time, a backlight and a discreet vibrate mode, where appropriate. The only running costs are those of standard batteries, which last on average one month. As with the Benetton pager, the retail price is £99.99, but you can always try shopping around for a better deal!

Designer Gear

Probably the centrepiece of the EasyReach portfolio is the Motorola/United Colours Pager, which has been designed solely to catch the eye of the youth market. In fact, BT is marketing the new tariff-free paging schemes to the younger MTV generation as a lifestyle and fashion product, and Benetton expects to achieve a 10% share of the consumer paging market in Europe, which is estimated to be worth US$800 million over the next five years. The multi-coloured numeric pagers come in three vibrant Benetton colours, perfect for those dedicated followers of fashion.

Billed as the world's first wristwatch pager that stays attached to you, the stylish Swatch the Beep has a distinctive personality of its own. The Swatch comes in six styles and with dimensions of just 21cm³, is certainly one of the world's smallest pagers. Swatch has managed to keep the size to a minimum, thanks to two patented design features: Integrated antenna, instantly recognisable as five metallic strips across the watch face, while the battery compartment is integrated into the watch strap. It gives a digital display for messages of up to 20 digits, with storage for up to ten messages. Swatch the Beep is also a high quality wristwatch, featuring a shock-resistant, 601,000-calibre quartz movement, specially developed for Swatch. Each newly received message is signalled by a series of beeps emitted from the wrist watch/pager lasting 10 seconds. The unit retails at £119.95, but again, try shopping around.



Smooth-shaped pager from Motorola.

Not to be outpaced, Mercury Pager has produced a CPP pager, MiniCall. The Motorola-made unit has a 12-digit display and 20 character message length, with up to eight or 16 messages being stored. Like the BT EasyReach range, it comes in several colours. There are two models to choose from – the Bravo Express, which weighs in at 67g with a battery life of 750 hours at £99.99, and the Lifestyle Plus, which has a weight of 83g and battery life of 2,000 hours, at £79.99. MiniCall, says Mercury, is a practical mobile communications tool that lets you do what you shouldn't be doing where you're not supposed to be doing it – if you get the drift. Sounds like just the item to solve that current patter – "Where do we chill out man?"

Just to complicate matters, TrafficMaster has now launched a CPP service through its YQ terminals. The world indeed looks like becoming a beeping place.

SOCIAL COMPUTING – *Continued from page 11.*

Summary

As on-line information services become an integral part of selling and marketing products, IT expertise will become critical to senior managers. To prepare itself for social computing, management information services (according to the law of Forrester Research, anyway) should:

Get involved early. In industries where social computing will first take root (consumer goods and financial services), IT management must get involved with the strategic planning process.

Start prototyping. Products like the Apple Newton message pad will provide hardware platforms for a first attempt at the new architecture. Good first steps will be supplementing existing customer service applications, electronic mail and calendaring systems, and Notes discussion databases with simple dial-up bulletin board capabilities.

Look for transitional technologies. Introducing marketing staff to CD-ROM players will give people an early taste of interactive digital content. This will suffice for a while (interactive TV is still years away). Also, companies can gain early experience putting product information bulletin boards up on the Internet (for example).

Plan on giving PC mutants away. The cost of the give-aways will be easily recouped. The innovative services delivered through these devices will cement customer loyalty, provide clear differentiation and increase sales (they hope).

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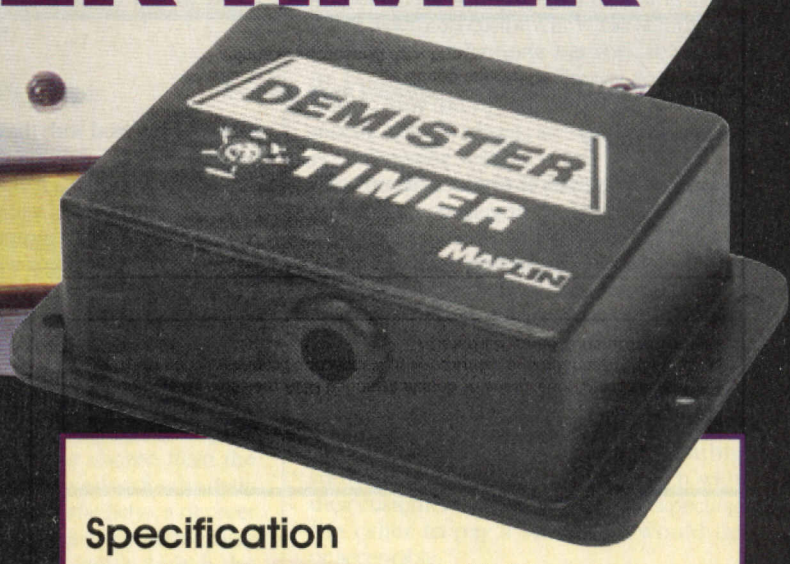
REAR WINDOW DEMISTER TIMER

KIT AVAILABLE (95027) PRICE £8.99

SAVES WEAR AND TEAR ON YOUR CAR'S BATTERY & SAVES ON FUEL!



1 PROJECT RATING

It costs money to buy petrol to fuel the engine to power the alternator to produce the electricity to demist the rear window of a vehicle. Most people switch the demister on when they cannot see through the rear window when viewed in the mirror, but more often than not, forget to turn it off again when the vehicle's air temperature rises sufficiently enough to prevent remisting, thus wasting precious energy. But do not despair! Equipping your vehicle with this simple to build and install demister timer will ensure that the demister will automatically be switched off after a preset period, even if you forget all about it; it will also squeeze a few extra miles out of your tank by not wasting petrol, as well as being kinder on the vehicle's hard-suffering battery (and alternator) in cold weather, leaving more power in reserve for the lights, windscreen wipers, the heater blower and, perhaps, your all-important stereo system!

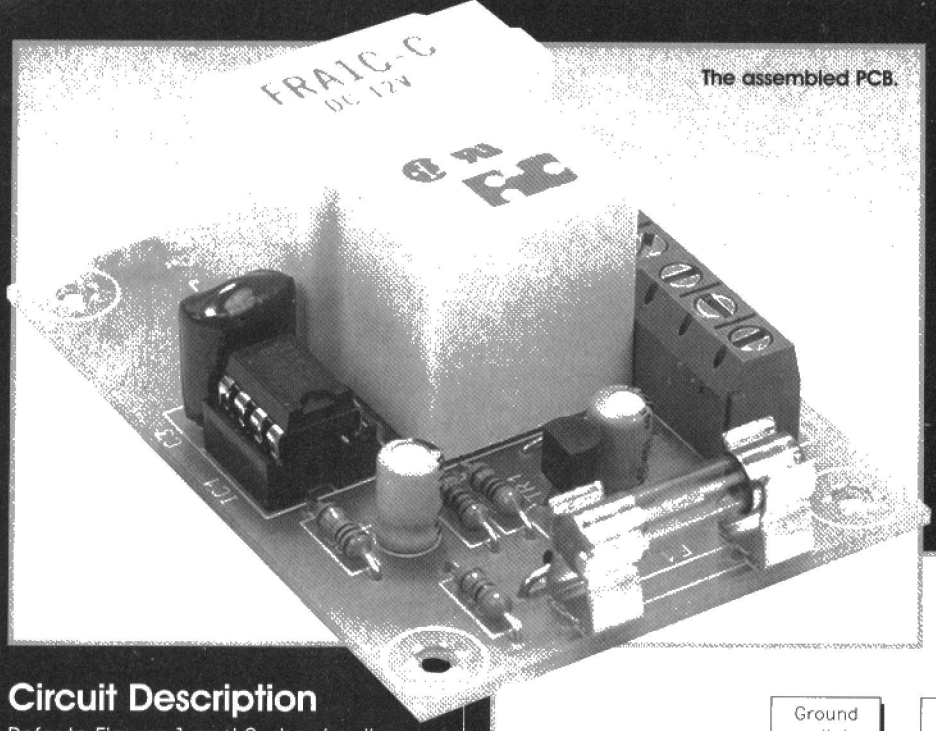
Specification

Operating voltage:	12V DC nominal
Operating current:	66mA
Standby current:	1·4mA
PCB dimensions:	65 × 72 × 25mm
Box dimensions:	105 × 72 × 33mm
Over-current protection:	100mA fuse

Design by Alan Williamson

Text by Alan Williamson and Maurice Hunt

Note: This project is suitable only for negative earthed vehicles with a 12V electrical system.



The assembled PCB.

on the existing demister switch on the vehicle, although an extra push-button can be fitted to allow instant retriggering of the timer after it has timed out, without the need for having to turn off and turn on again the demister switch. This supplementary push switch may be connected to the ground switching input via D2, marked as the (⌐) terminal on the PCB, though transistor TR1 is included to provide a complementary supply switching input (marked (¬) on the PCB), should this be required. The relay is also designed for automotive use, and is rated for currents of up to 16A. Supply protection is provided in the form of D1 and F1; should a reverse polarity be applied to the circuit, D1 will clamp the voltage to –1V across the circuit; damaging current flow is prevented by the fuse F1 blowing.

Circuit Description

Refer to Figures 1 and 2, showing the block and circuit diagrams of the Rear Window Demister Timer.

R1 and C1 provide supply filtering to IC1, which is a long duration timer, specifically designed for automotive use. The IC contains an oscillator, divider, input debounce circuits, an integrated supply protection Zener diode and a load dump protection diode for driving reactive loads. The IC has three inputs – TOGGLE, ON and OFF; only the ON input is used in this application. R5 and C3 set the duration of the timer; in this case, to approximately 10 minutes.

Diode D4 and C2 (the components marked with an asterisk in Figure 2) are optional; if fitted, the timer will automatically trigger when the ignition is turned on (that is, if the demister switch is in the 'ON' position); should this feature not be required, omit the components. The timer is normally triggered by turning

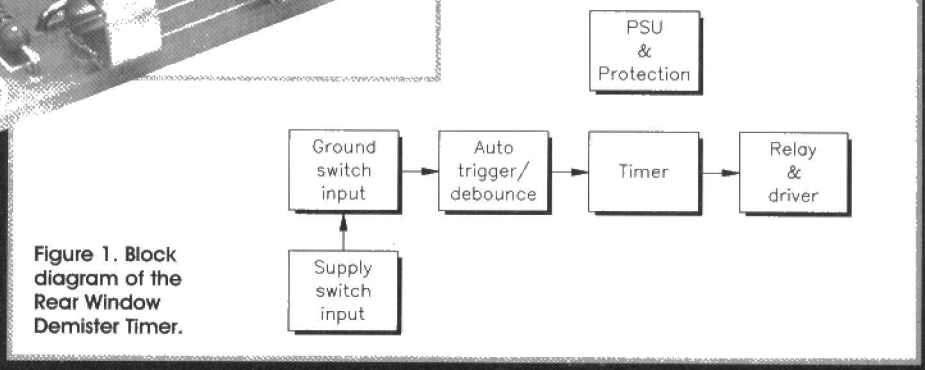


Figure 1. Block diagram of the Rear Window Demister Timer.

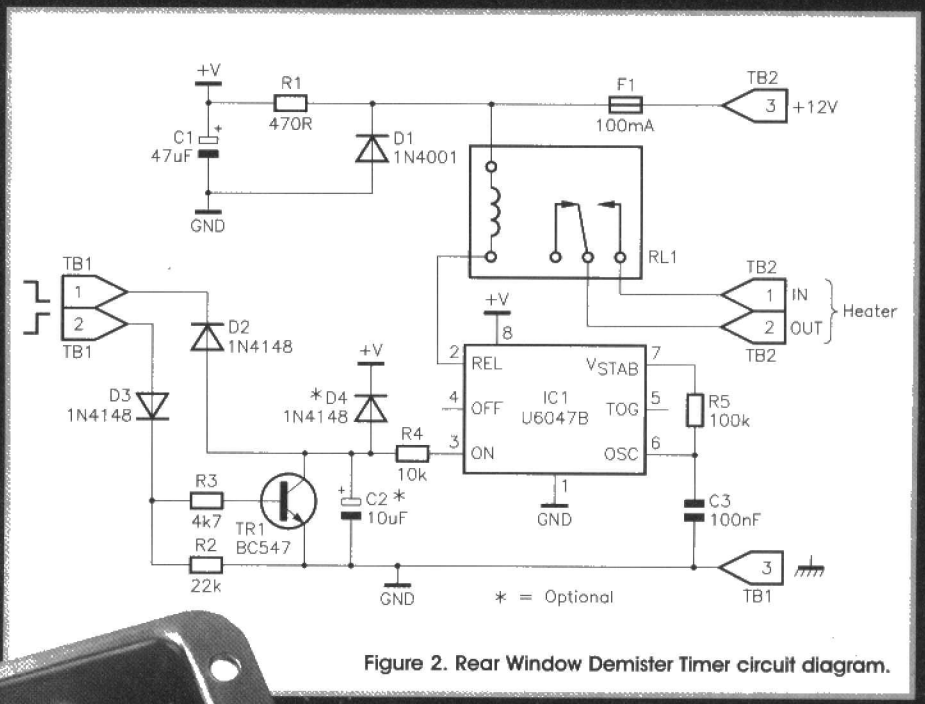
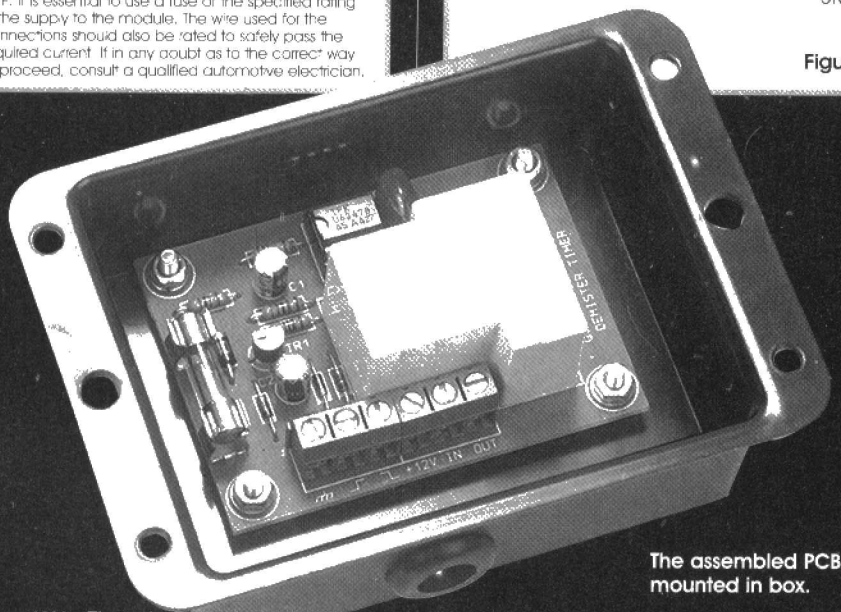


Figure 2. Rear Window Demister Timer circuit diagram.

IMPORTANT SAFETY WARNING

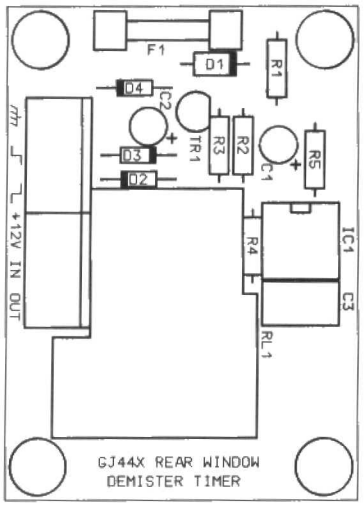
Before starting work, consult the owners manual regarding any special precautions that apply to your vehicle. Since a car battery is capable of delivering extremely high currents, it is imperative that every possible precaution is taken to prevent accidental short circuits occurring. Remove all items of metal jewellery, watches, etc. Before connecting the module to the car electrics, ensure that the vehicle ignition is switched OFF. It is essential to use a fuse of the specified rating in the supply to the module. The wire used for the connections should also be rated to safely pass the required current. If in any doubt as to the correct way to proceed, consult a qualified automotive electrician.



The assembled PCB, mounted in box.

PCB Construction

Figure 3 depicts the PCB legend and track. The PCB is of the high quality glass fibre variety, and as supplied, has solder resist and a silk-screen legend to aid construction. Assembly of the PCB is fairly straightforward; begin with the smallest components first, working up in size to the largest. Be careful to correctly orientate the polarized devices, i.e. electrolytic capacitors, diodes, transistor and IC (and its holder). The fuseholder clips will be easier to install if the fuse is



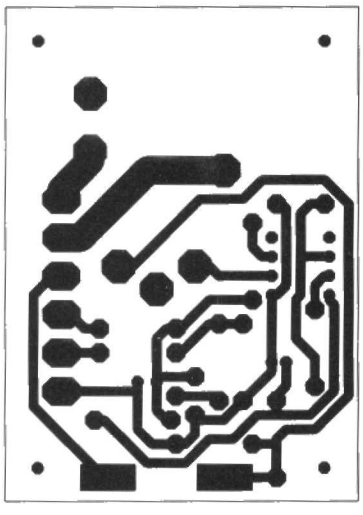


Figure 3. PCB legend and track.

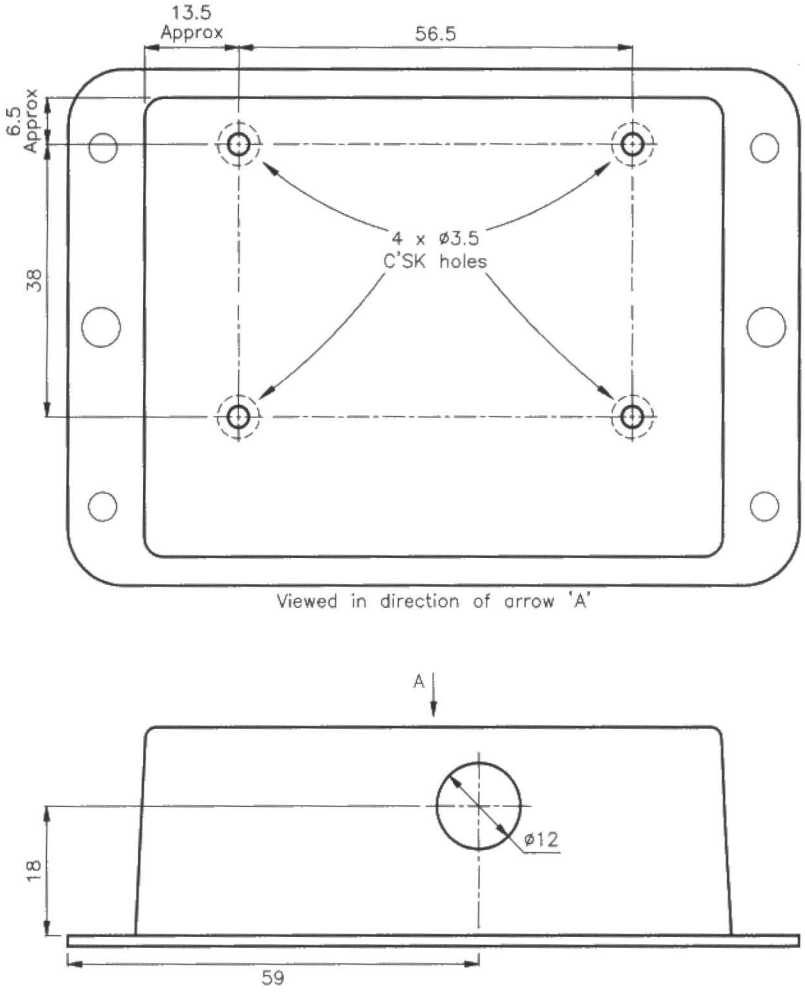


Figure 5. Box drilling details.

clipped into them beforehand. Fit the terminal blocks together in accordance with the diagram shown in Figure 4, and fit them onto the board so that the cable aperture holes face outwards. Next, plug the IC into its socket, taking suitable antistatic precautions, and trim excess component leads from the underside of the PCB. Last of all, thoroughly check your work for misplaced components, solder whiskers, bridges and dry joints. Finally, clean all the excess flux off the PCB using a suitable solvent.

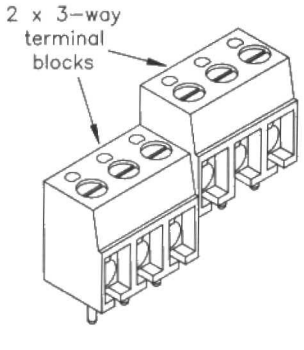


Figure 4.
Arrangement of the terminal blocks.

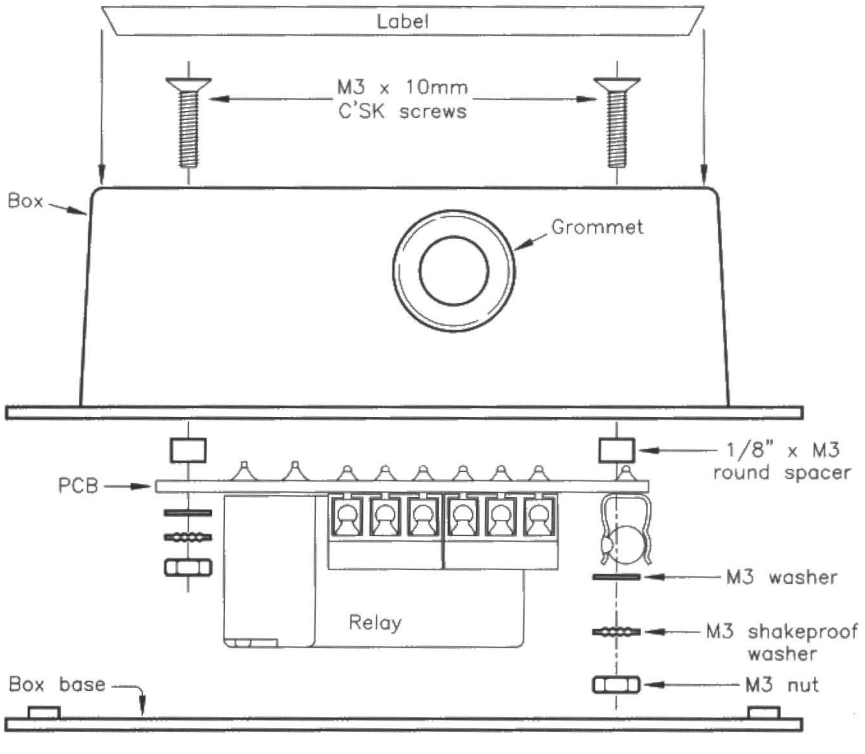


Figure 6. Exploded assembly diagram.

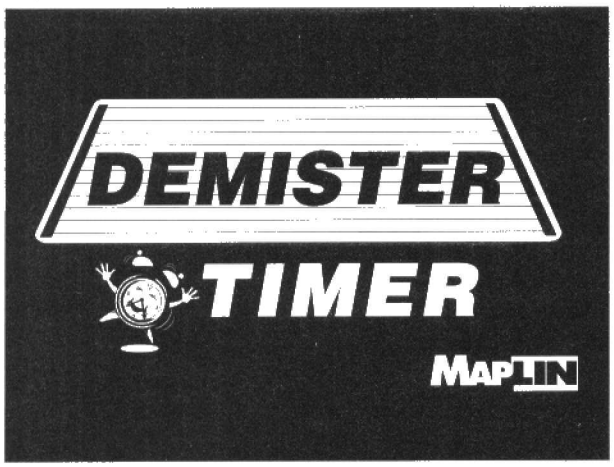


Figure 7. Front panel label.

The assembled Demister Timer in the recommended Optional box.

Testing

If the capacitor C2 is fitted, simply powering up the circuit will immediately energize the relay; wait approximately 10 minutes for IC1 to time out, the relay should then drop out. Then connect one end of a test lead to the +12V terminal, then briefly connect the other end of the test lead to the supply switching (⎍) input, which should result in the relay being energized again. Wait until the relay drops out before completing the last test. This time, connect one end of a test lead to the GND terminal, then briefly connect the other end of the test lead to the ground switching (⎍) input; the relay should once again energize. The Demister Timer is now fully tested and can be installed into the recommended Optional box.

Box Construction

Figure 5 shows the drilling information for preparation of the box, which should be of the plastic variety. Note that the PCB securing screws should be countersunk, so that they do not protrude from the face of the box. This can be achieved either by using an appropriate drill bit, or by placing the screws into the holes and heating them with a soldering iron, just enough so that they sink the required depth into the panel; do this in a well-ventilated environment. Remove burrs from the drilling process and wipe the box clean. Having tested the assembled PCB to ensure correct operation, install it into the box as shown in the exploded assembly diagram of Figure 6. Finally, affix the front panel label shown in Figure 7.

Installation

Prior to installing the unit into a vehicle, read the safety warning printed in this article. Ensure that the vehicle's ignition is switched OFF during the installation work. Consult the wiring diagram for the vehicle to determine and locate the wiring for the rear window demister and its switch. The existing wire between the demister switch and the heater element

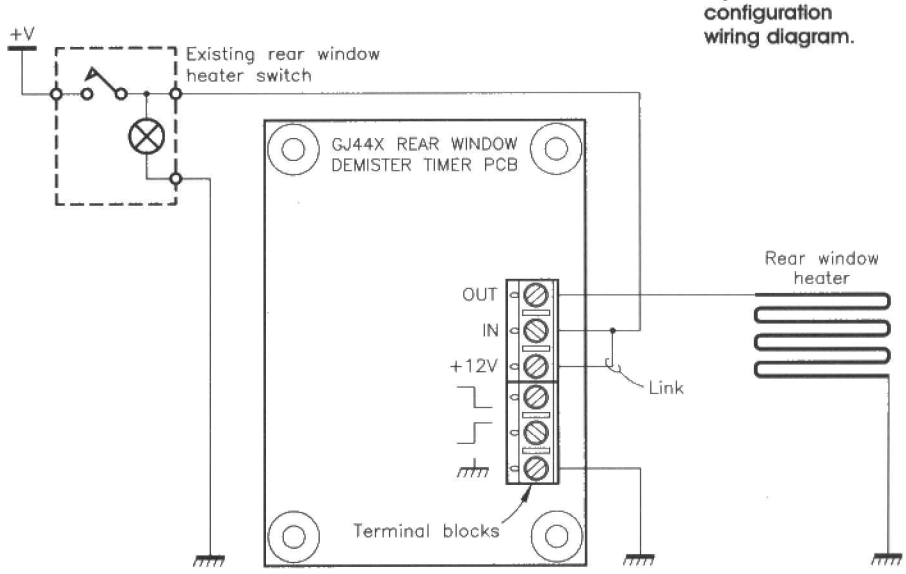


Figure 8. Minimum configuration wiring diagram.

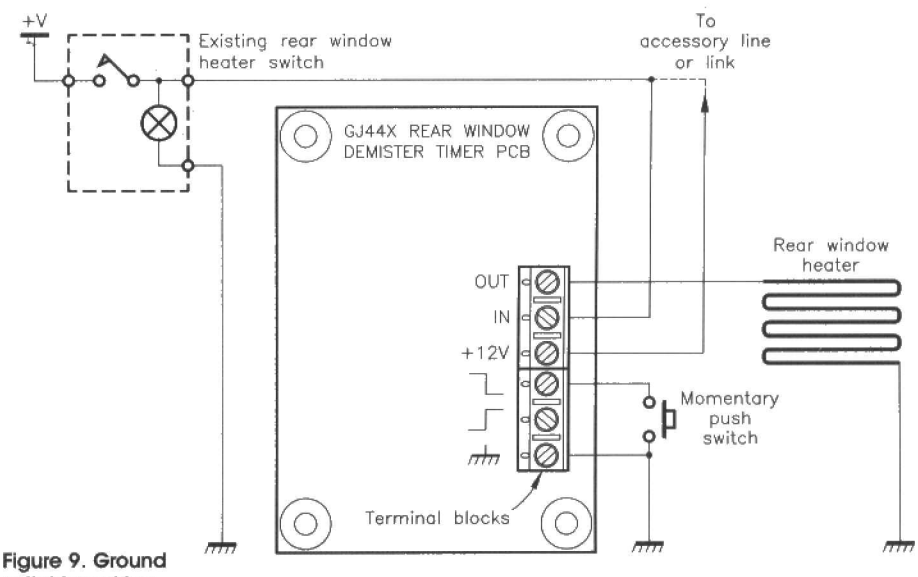


Figure 9. Ground switching wiring diagram.

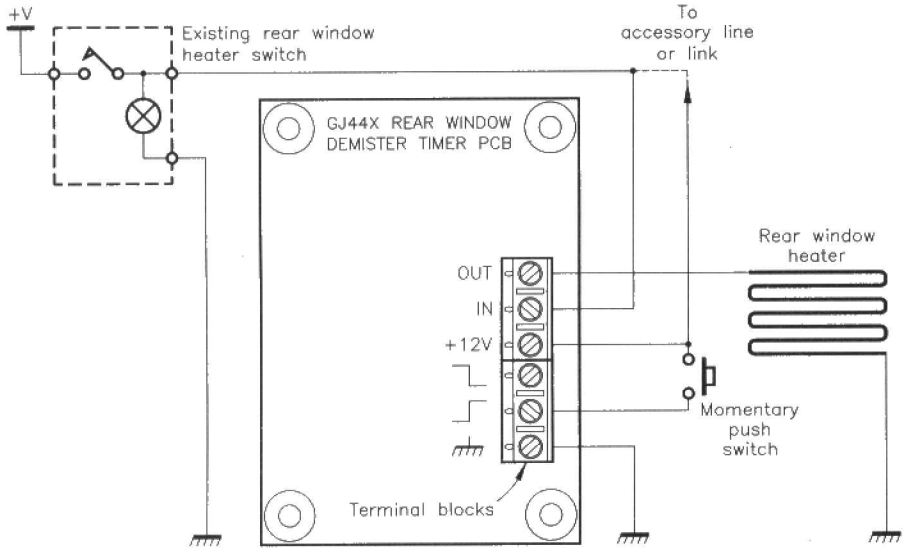


Figure 10. Supply switching wiring diagram.

is broken at a convenient point (such as at the connector to the heater itself), the wire from the switch being connected to the IN terminal, and the wire to the heater element being connected to the OUT terminal – refer to Figures 8 to 10 for the different wiring configurations possible with this unit. Figure 8 shows the basic configuration wiring, but the addition of the additional push switch shown in Figures 9 and 10 allows the timer to be instantly retriggered at any time after the timeout period without the need to turn off and on the demister switch. Figure 9 shows the ground switching wiring (the preferred option, since it is usually easier to implement with a negative-earthed vehicle); Figure 10 shows the supply switching wiring. The choice of push switch used is a matter of personal aesthetic preference, or whatever happens to suit the vehicle (there may already be a spare switch installed in the vehicle that could be used). However, it must be of the push-to-make type, suitable examples being FH91Y, RK82D (both round), JB00A, JB01B, FF96E or FF98G (all square). A suitable bracket may have to be fabricated for under-dashboard fitting – ensure that it is mounted in a safe location, where it will not cause injury.

The wiring between this unit, the demister switch and the heater element must be done using cable of a rating that at least matches that of the existing wiring – it is advisable to use as much of the existing demister wiring as possible. The wiring to the supplementary switch may be of a lower rating – general hook-up wire is adequate. Ensure that grommets are used where cables pass through holes in bulkheads, etc., to prevent the risk of chafing and short-circuits, secure the cables so that they do not get in the way of the driver or passengers – they can be hidden behind the trim panels, carpets, etc. The unit should be mounted in a convenient location in the vehicle (using two screws/bolts to secure it in place), and preferably hidden out of sight such as beneath the rear parcel shelf or behind a trim panel. However, ensure that the unit is protected from moisture ingress (check that the window/door/boot seals in the vicinity are sound), and away from excessive heat. If the unit is fitted into the boot of the vehicle, mount it so that it is protected from the possibility of heavy objects coming into contact with it in the course of using the vehicle.

REAR WINDOW DEMISTER TIMER PARTS LIST

RESISTORS: All 0·6W 1% Metal film (Unless specified)			
R1	470Ω	1	(M470R)
R2	22k	1	(M22K)
R3	4k7	1	(M4K7)
R4	10k	1	(M10K)
R5	100k	1	(M100K)
CAPACITORS			
C1	47µF 25V Axial Electrolytic	1	(AT47B)
C2	10µF 63V Axial Electrolytic	1	(AT77J)
C3	100nF Mylar Film	1	(WW21X)
SEMICONDUCTORS			
D1	1N4001	1	(QL73Q)
D2-4	1N4148	3	(QL80B)
TR1	BC547	1	(QQ14Q)
IC1	U6047B	1	(AH44X)
MISCELLANEOUS			
RL1	16A/12V Car Relay	1	(JM26D)
F1	Fuse 20mm 100mA	1	(WR00A)
TB1,2	3-way 5mm PCB Mounting Terminal Block Type 300	2	(JY94C)
	8-pin DIL Socket	1	(BL17T)
	20mm Fuse Clip Type 2	2	(KU27E)
	Front Panel Label	1	(95034)
	PCB	1	(95028)
	Instruction Leaflet	1	(XV89W)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
	Box and Base Type 2	1	(YN36P)
	9·5mm Grommet	1	(JX63T)
	M3 × 12mm Pozi-drive Screw	1 Pkt	(BF37S)
	M3 Steel Nut	1 Pkt	(JD61R)
	M3 Steel Washer	1 Pkt	(JD76H)
	M3 Shakeproof Washer	1 Pkt	(BF44X)
	M3 × ⅛in. Spacer	1 Pkt	(FG32K)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.

Order As 95027 (Rear Window Demister Timer) Price £8.99

The following new items (which are included in the kit) are also available separately, but are not shown in the 1996 Maplin Catalogue.

Catalogue Rear Window Demister Timer PCB

Order As 95028 Price £2.29

Rear Window Demister Timer Front Panel

Order As 95034 Price £2.29

The Revolution in MICROSCOPY

by Douglas Clarkson

Much of the development of science in all its many branches is related to 'seeing' what is taking place in materials and living things. Science, however, was greatly limited in what it could observe before the development of the microscope. With the unaided eye, objects as small as 50μm (microns) can be resolved.

WHILE in conventional optical microscopy, incremental changes are taking place to improve the resolution and optimise ease of use of microscopes, whole new areas of microscopy at the atomic and molecular level are rapidly developing and providing new tools with which to study the properties of materials and even help unravel the mysteries of DNA. Interfaces with computers are providing systems of rapid image processing and archiving in sophisticated database systems.

While conventional light microscopy deals with wavefronts of light, newer forms of atomic microscopy are sensing atoms in ways that do not involve any 'optical' interaction. Examples of this include the Scanning Tunnelling Microscope which 'senses' the position of atoms by the level of 'tunnelling' current which flows from a tunnelling probe into the material being investigated. This field of 'indirect' microscopy is also one that is expanding very rapidly as new physical effects are detected at the atomic scale.

Before these more recent developments are outlined, it is perhaps appropriate to review the development of conventional microscopy and highlight some recent innovations in this field.

In the Beginning

While Galileo is credited with documenting the use of a microscope around 1610 to make a fly look 'as big as a hen', it is not clear when and where the very first observations were made. Some would suggest that the Arabs were the first to use microscopes successfully, although in Europe, the credit is usually given to Hans and Zacharias Janssen of Middleburg in the Netherlands as the first manufacturers. One of the early works of microscopy was 'Micrographia' – published by the English physicist Robert

Photo 1. Typical image obtained of Diatoms (fossil algae) at 200× magnification using a Leica Stereoscan 440 Scanning Electron Microscope. (Courtesy, Leica, Cambridge, UK.)

Accelerating Voltage (kV)	Electron Velocity (× 10^8m/s)	Relative mass	Effective Wavelength (nm)
10	0·586	1·020	0·0122
20	0·816	1·039	0·0086
30	0·986	1·059	0·0070
40	1·123	1·078	0·0060
50	1·239	1·098	0·0053
60	1·340	1·118	0·0049
70	1·429	1·137	0·0045
80	1·508	1·157	0·0042
90	1·580	1·176	0·0039
100	1·646	1·196	0·0037
110	1·706	1·216	0·0035
120	1·761	1·235	0·0033
130	1·812	1·255	0·0032
140	1·860	1·275	0·0031
150	1·904	1·294	0·0030

Table 1. Values of velocity, relative total mass and effective wavelength (nm) for electrons accelerated to to specific voltages within the range 10 to 150kV.

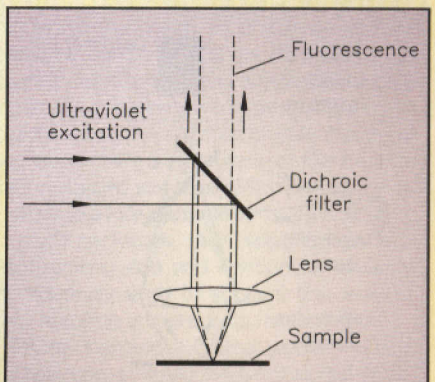


Figure 1. Fluorescence microscopy of sample. Light from an ultraviolet source or laser system excites emissions from activated elements, which are in turn, selectively imaged by the optical system.

Hooke in 1665. At the time, all observations had to be meticulously illustrated.

It was however, the partnership between Ernst Abbe, a Physicist at the University of Jena (for a time in East Germany) and Carl Zeiss, a German manufacturer of optical instruments around 1870 which led to the optimisation of the performance of light microscopes. A basic calculation identified by Abbe was that the resolution of objects was limited at approximately 1·5 times the wavelength of light used for the observation. For blue light at 400nm, this provided a limit at around 0·6μm. Under certain conditions, however, resolution can be achieved with conventional microscopy down to 0·2μm.

Waves and Particles

Use of ultraviolet (UV) radiation has generally proved unsuccessful to improve object resolution. Much more successful has been the use of accelerated electrons – at voltages as high as 300kV in the scanning electron microscope (SEM). Such systems have been able to resolve structures as small as individual atoms. Unless very much higher voltages are utilised, such systems can only be used to study very thin sections of around 0·1μm thickness, and specimens must be scanned in a vacuum. Thus, while much higher resolution can be achieved, sample throughput is limited and specialist skills are required in the preparation of samples. According to the De Broglie equation, the effective wavelength of a particle with mass m and velocity v is given by:

$$wavelength = \frac{h}{mv}$$

Where h is Planck's constant. As electrons are accelerated in a high voltage field, a significant amount of the energy acquired from the electric field increases the mass of the particle according to relativity theory – see Table 1.

This indicates that electrons even under moderate voltages behave as waves with short equivalent 'wavelengths'. At 50kV, the de Broglie wavelength of 0·0053nm compares favourably with the wavelength of 400nm of conventional optical systems. In reality, the maximum resolution typically attained at voltages around 300kV is one Angstrom (0·1nm), with medium performance systems having a resolution of 3·3nm at 30kV. Photo 1 indicates a typical image obtained from an SEM system.

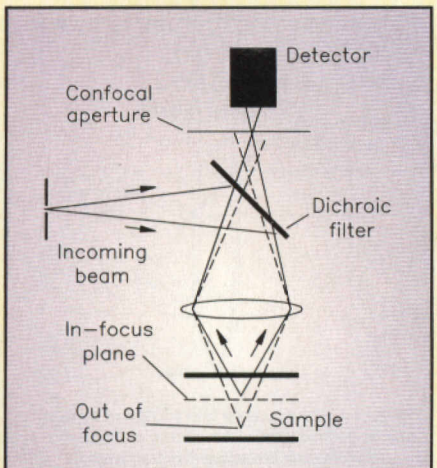


Figure 2. Principle of the confocal microscope: by Light from a source in the image plane is focused by lenses and selectively detected a detector system. Light from above and below the focal plane is rejected by the system, allowing improved contrast of the objects in the selected focal plane.

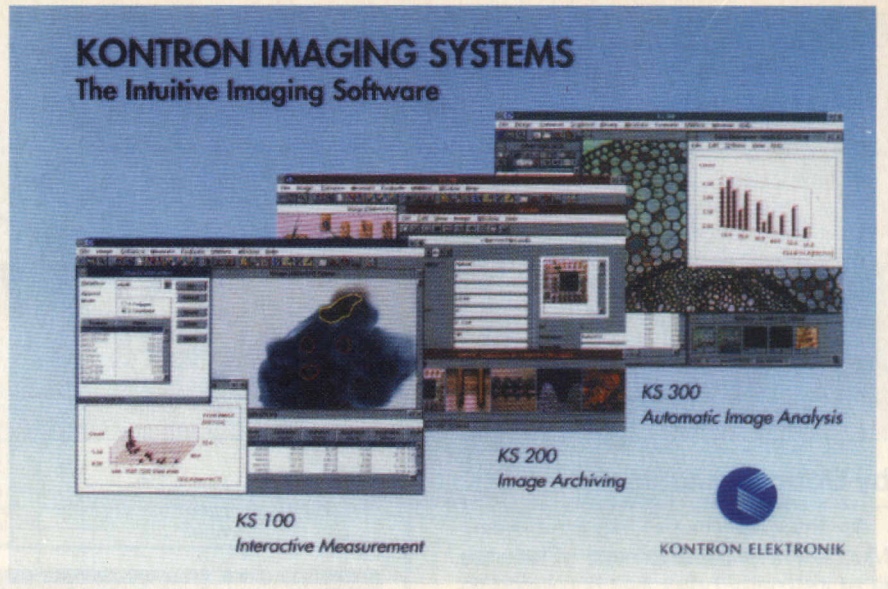


Photo 2. Typical appearance of a display screen of captured and processed microscope images retrieved from a data base system. (Courtesy Kontron Electronik.)

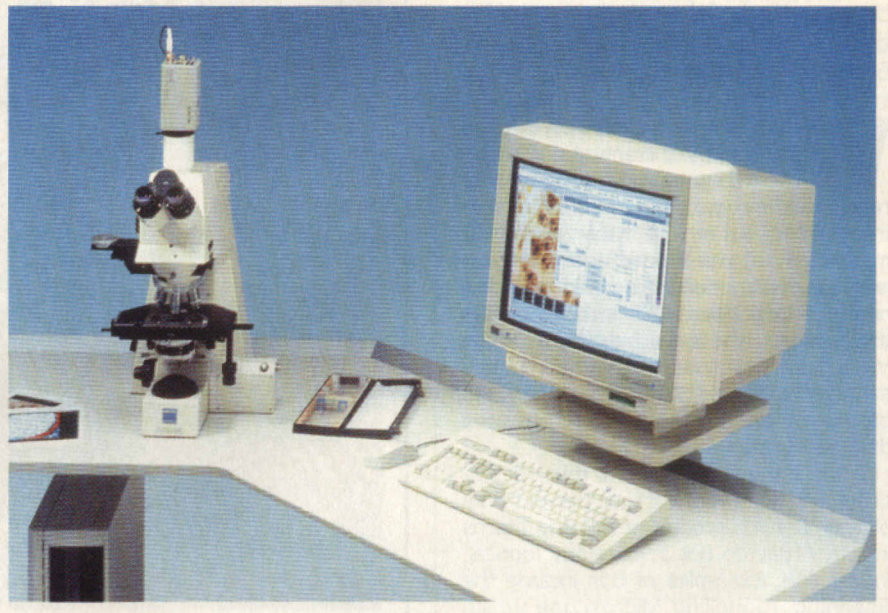


Photo 3. A typical modern optical microscope system with high resolution TV camera interfaced to modern image processing and management software system. (Courtesy Kontron Electronik.)

Video Processing

The range of options available with video capture of conventional optical microscope images and the processing which can be undertaken on them has led to a significant improvement in the size of objects which can be detected. This improvement, roughly of a factor of 10, has come about chiefly as a result of improved contrast within the image due in the main to processing of individual pixel data in the image. This has led in turn to a rapid development of optical microscope systems with video processing subsystems to optimise the contrast available and allow observation of smaller objects. Such work has allowed single molecules of DNA to be studied, even though they are only 2nm across.

Fluorescence Microscopy

The principle of fluorescence microscopy is to provide images from the light which is emitted by structures after having been irradiated with shorter wavelengths of light. Ultra violet light is typically used to initiate this effect.

Figure 1 indicates how ultraviolet excitation is reflected onto the sample by a dichroic filter. Light of longer wavelength emitted due to fluorescence is in turn transmitted by the dichroic filter to the lens optics of the microscope, though the shorter wavelength UV light is not transmitted. This technique is made possible with the addition of fluorophores, special molecules that fluoresce when exposed to light. Use can be made of laser radiation to deliver high levels of 'incident' light intensity.

One problem when high intensity ultraviolet lasers are used is that such radiation can result in cell damage and destruction of the fluorophores themselves. In 'standard' fluorescence, a fluorophore will absorb a

single high energy photon and emit one at lower energy. In 'two photon' fluorescence, a fluorophore molecule is able to simultaneously absorb two low energy photons and emit a single photon of higher energy. One group at Cornell University has been able to irradiate samples with pulses of 100 femto second pulses of red light and stimulate emissions of green/yellow light without damaging the cell being observed. As laser technology has progressed, a range of dye materials for use in dye laser systems has been developed. Dyes used in fluorescence studies include fluorescein at 496nm (blue green), lessamide rhodamine at 572nm (green) and cynamine 5 at 649nm (red).

Confocal Microscopy

While resolution of observed structures is a key factor of microscope function in scanning across a light image, the relative contrast across the image can often be equally important.

Depending on the thickness of the sample, light from zones above and below the in-focus plane will also contribute to the total image from the in focal plane. This places limitations on the thicknesses of samples which can be examined. A large part of conventional microscopy relates to the preparation of thin samples in order to minimise loss of contrast by the travel of light through intervening layers.

One of the key developments to improve contrast is the confocal microscope, shown in Figure 2. Blue or ultraviolet light is reflected from an incoming beam by a dichroic filter onto the sample. As the sample fluoresces, i.e. gives off light as a result of stimulation by the incident radiation, such light from a specific plane of the sample is able to pass through the confocal aperture and be detected by the detection system. Light from above and below the plane of focus is rejected by the detection system. When such a system has been linked with computer capture of images, it is possible to obtain images over thin sections and step through a relatively thick sample and then later recreate a three-dimensional image of the sample being scanned in this way. Such a technique is especially useful, for example, in the examination of neural tissue, where the neural linkages can be identified without sample destruction. Time resolved studies using laser scanning techniques have allowed insight into the dynamics of chemical activity within complex living cells. In particular, such studies have revealed new information about such basic processes as fertilisation of the human egg by sperm. This has also led to improved understanding of the participation of the glial cells in the brain. While this activity is not as dynamic as that of the neurons themselves, the action of such glial cells is probably a key factor in degenerative processes such as Alzheimer's disease.

Confocal microscope technology was initially used to scan thick samples. There are now applications for three-dimensional surface analysis using laser scanning techniques where image detail is obtained from sequential scanning layers and then reconstructed into a processed image. Scanning resolution is increased with additional scan time – 0·25μm at 3 seconds and 0·1μm at 10 seconds. A measurement range of 0·1 to 600μm can be scanned.

Optical Archiving

As technology has developed to allow images to be captured by computer, so sophisticated archiving software has been developed to store, annotate and retrieve images. This form of archiving is particularly suited to the Windows graphics environment, where a series of images of the one feature can be displayed on a single computer screen. Photo 2 indicates the typical graphical displays that can be produced by such software. Also, the captured images can be extensively processed by software routines, pixel by pixel to produce a wide range of 'hidden' data relating to the image, which can be used to enhance contrast, display distribution of intensity across selected areas. Where cells are imaged, software can be configured to rapidly count the number of cells displayed and even draw a histogram of numbers of cells in specific size categories. Speed of processing is a key element of the specification of such packages. High specification PCs incorporating 486 and Pentium processors are routinely used to support this level of data handling and graphics manipulation.

Photo 3 shows a typical modern optical microscope system with attached high-resolution TV camera interfaced to a PC system running imaging software, as shown in Photo 2. High-performance scanning cameras can now capture images with a resolution of 4,400 by 3,500 pixels, at 24 bits of resolution per pixel. An image stored at 1,000 × 1,000 resolution at 24 bits would require, without data compression, some 3M-bytes of disk storage.

Continued on page 26.

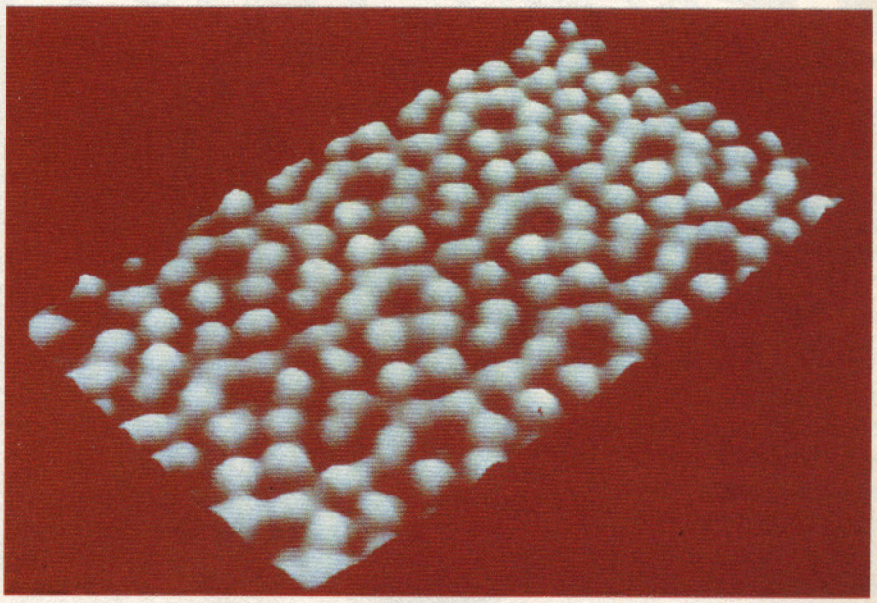
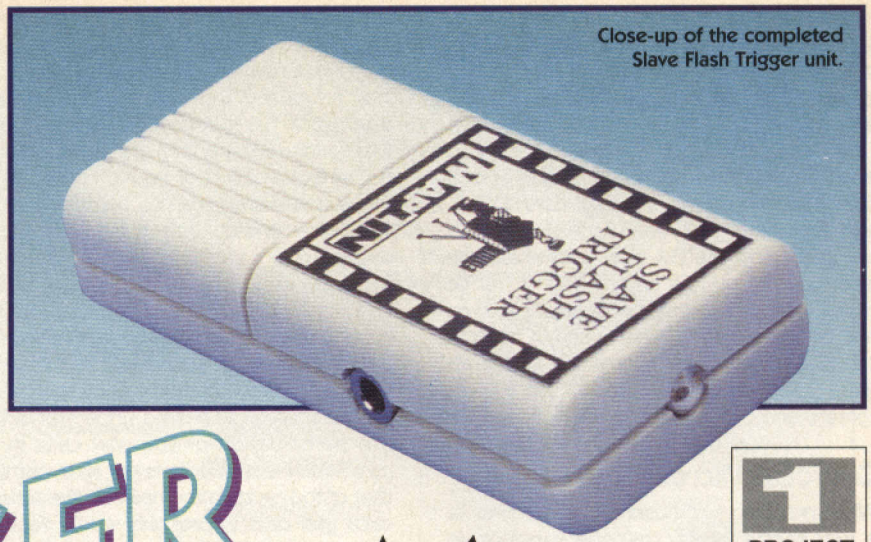


Photo 5. Image obtained of silicon using the Scanning Tunnelling Microscope. (Courtesy IBM Research.)

Photo 4. The inventors of the Scanning Tunnelling Microscope (STM). Gerd Binnig (left) and Heinrich Rohrer (right). (Courtesy IBM Research.)

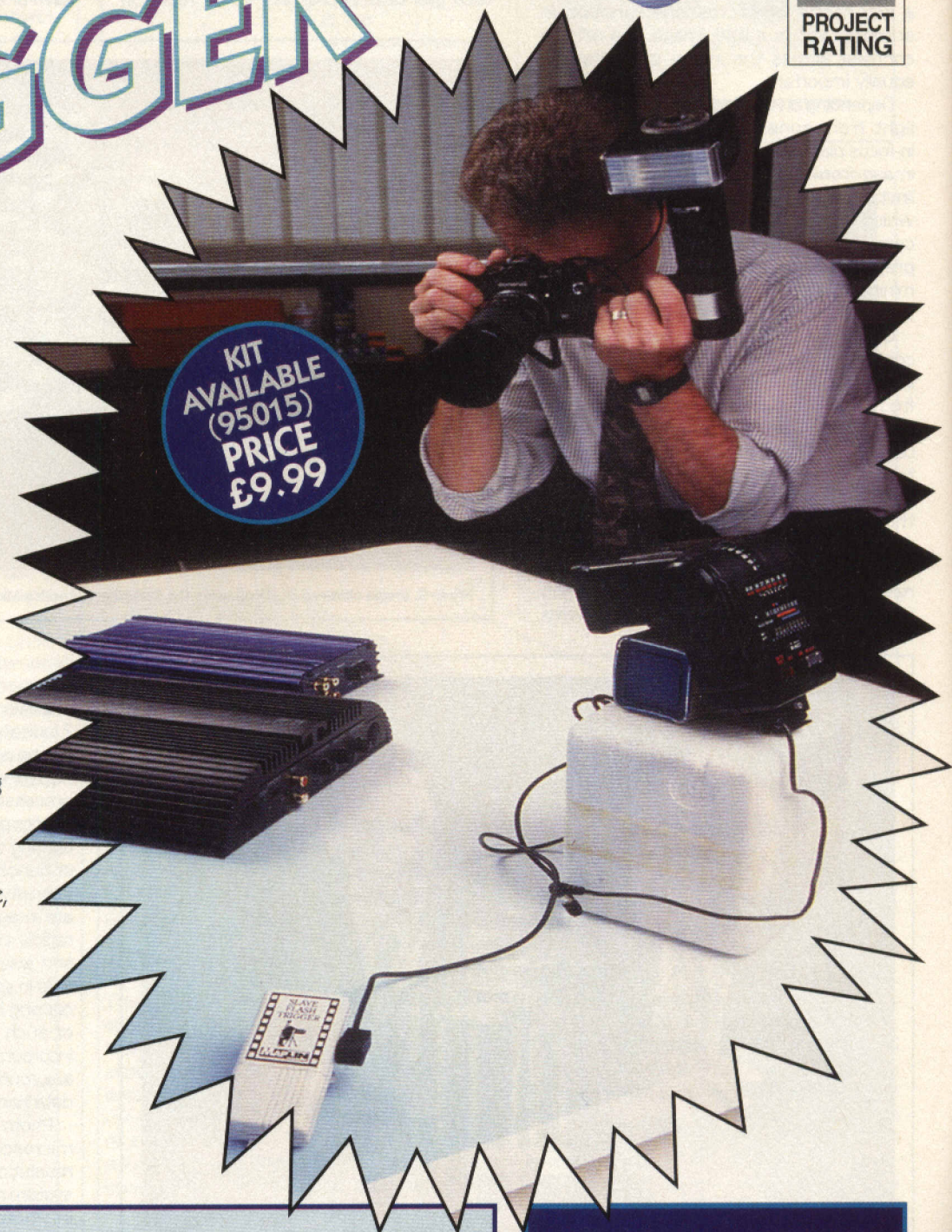
Design by Alan Williamson
Text by Alan Williamson
and Maurice Hunt



Close-up of the completed Slave Flash Trigger unit.

SLAVE FLASH TRIGGER

1 PROJECT RATING



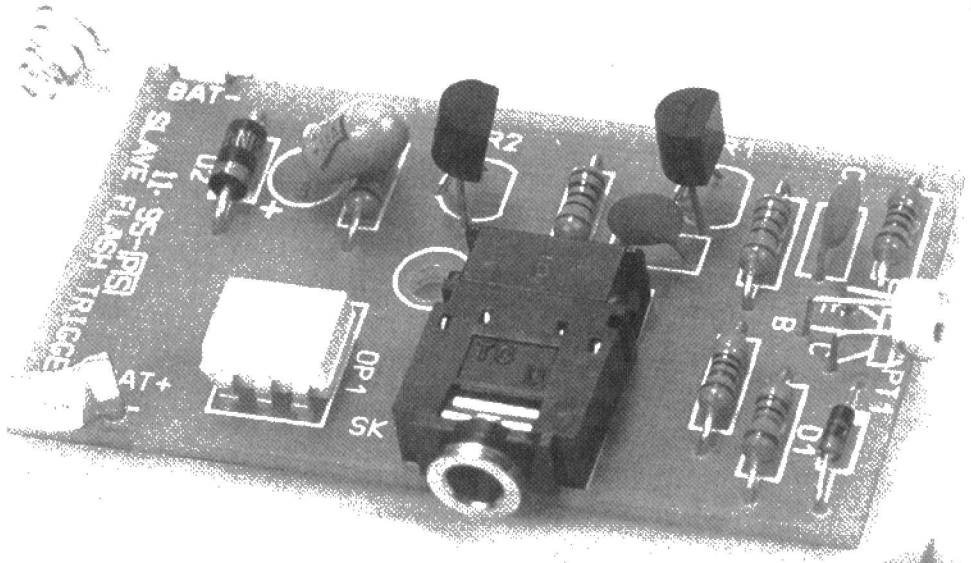
An essential project for 'serious' photographers, this circuit enables additional slave camera flash units to be triggered without direct electrical connection to the camera outfit itself, but merely by being within 'sight' of the light from the main flash unit – which can be several metres away, even in a brightly lit room. A phototransistor is used as the sensor, which is very sensitive to sudden changes of light, despite being 'detuned' in this application, to prevent spurious triggering from unintentional light level changes – caused for example, by shadows from someone moving around in the vicinity.

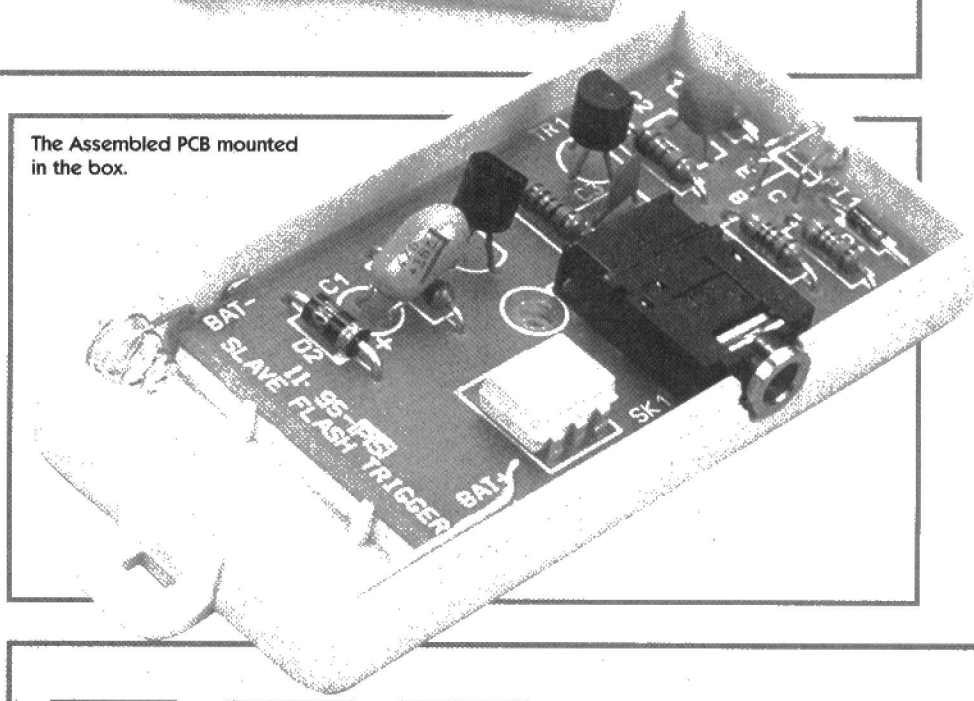
Specification

Supply voltage:	6 to 15V DC (12V nominal, from 12V battery, type GP23A)
Operating current (quiescent @12V):	690μA to 3·2mA, dependent on light level
Operating current (activated @12V):	15mA maximum
PCB dimensions:	32 × 56mm

Warning: High voltages can be present on the terminals of some flash-guns. Therefore, care should be taken at all times when handling or interfacing flash-guns to this project.

The Assembled PCB.





The Assembled PCB mounted in the box.

THERE is no limit to the number of Slave Flash Trigger units that can be used, all triggered remotely from the main flash-gun. This allows for a very comprehensive flash lighting setup to be implemented if required, ideal when taking photographs of a wide scene, where shadows caused by using just one flashlight are to be avoided, such as stage productions, display stands, and the interiors of buildings or vehicles. The only proviso is that the project is only suitable for use with modern flash units, incorporating an external triggering socket for the unit to be plugged in to, or having a hot-shoe adaptor. However, be warned: use of this project could lead to a dramatic improvement in the results of your photographic exploits!

Circuit Description

Refer to the block and circuit diagrams of the Slave Flash Trigger, shown in Figures 1 and 2, respectively. PT1 is the flash sensor, which is made 'deaf' (a not particularly apt engineering expression) by connecting the base to the emitter; in doing so, PT1 will not readily react to ordinary changes in light and shade. A high intensity burst of light, however, such as that from a camera flash-gun, will cause PT1 to conduct briefly, producing a small voltage pulse across R1. The voltage pulse is AC-coupled to the high gain amplifier, TR1. C3 AC-couples the collector of TR1 to the base of TR2 which saturates on, illuminating the LED within the opto-triac and in turn, triggering the triac into conduction; this, in turn, fires the flash-gun. An opto-triac was chosen because it provides total isolation from the circuit and because it is a bidirectional device, therefore, it is irrelevant which way round the trigger lead is wired.

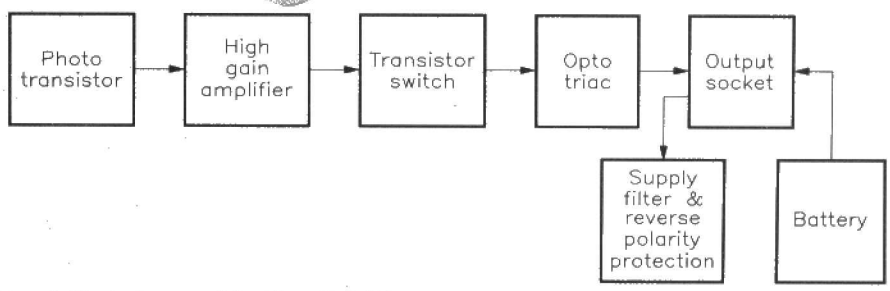


Figure 1. Block diagram of the Slave Flash Trigger.

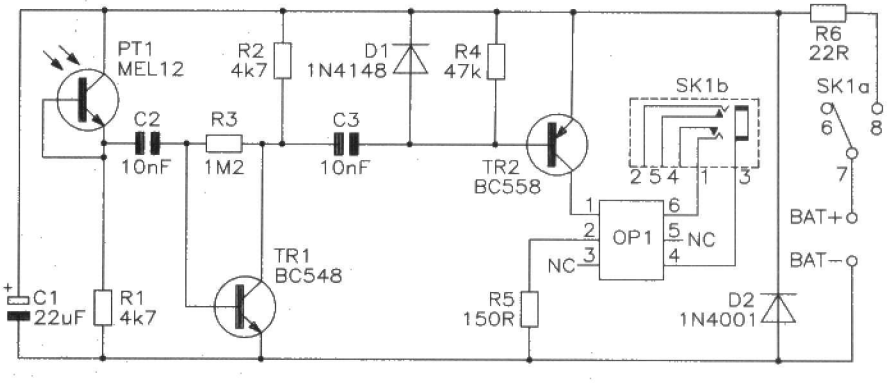


Figure 2. Slave Flash Trigger circuit diagram.

Construction

Refer to Figure 3 when building up the board, which shows the PCB legend and track. The PCB is a high quality glass fibre board, incorporating solder resist on the tracks, and a silk-screen legend to aid construction. Construction is straightforward: begin with the smallest components first, working up in size to the largest. Insert the PCB pins from the track side. Be careful to

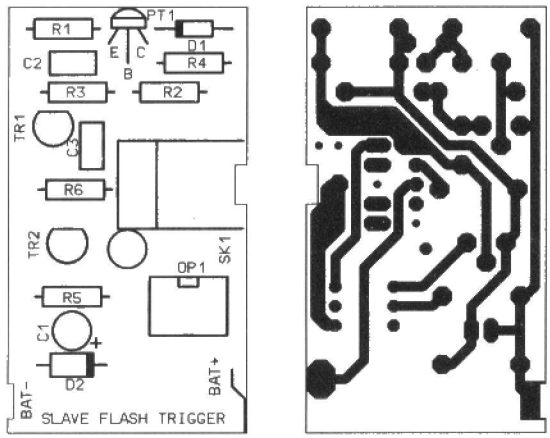
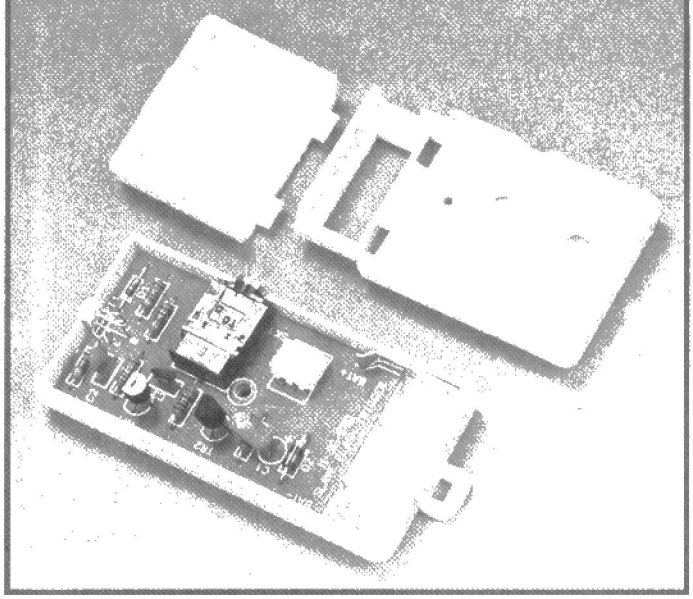
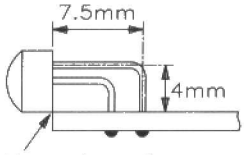
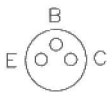


Figure 3. PCB legend and track.





Line edge of opto transistor with edge of PCB



View from below

Figure 4. Phototransistor mounting details.

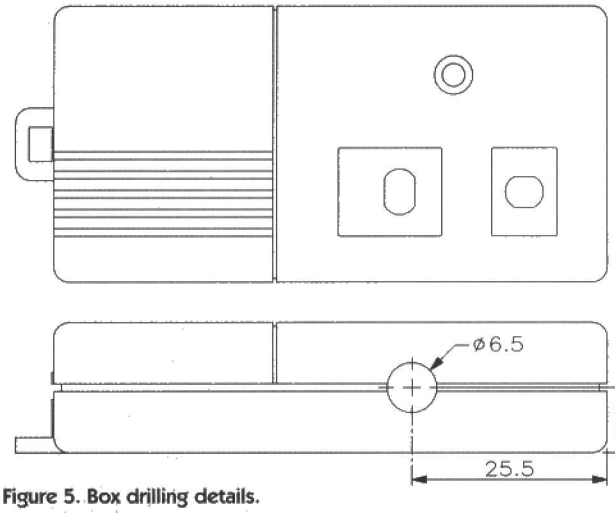


Figure 5. Box drilling details.

Figure 6. Front panel label.

correctly orientate the polarized devices, i.e. the electrolytic capacitor C1, diodes D1 and D2, transistors TR1 and 2, phototransistor PT1, and the opto-triac, OP1. Refer to Figure 4 for fitting the phototransistor, and to the next paragraph for details of the battery terminals.

The box drilling details are shown in Figure 5; once completed, wipe the box clean, and attach the front panel label (see Figure 6). Solder the battery terminals to the PCB as shown in the exploded assembly diagram of Figure 7, observing the correct battery orientation printed on the PCB legend. Having completed assembly of the board, thoroughly check your work for misplaced components, solder whiskers, bridges and dry joints. Finally, clean all the excess flux off the PCB using a suitable solvent, then complete the assembly of the unit, as shown in Figure 7.

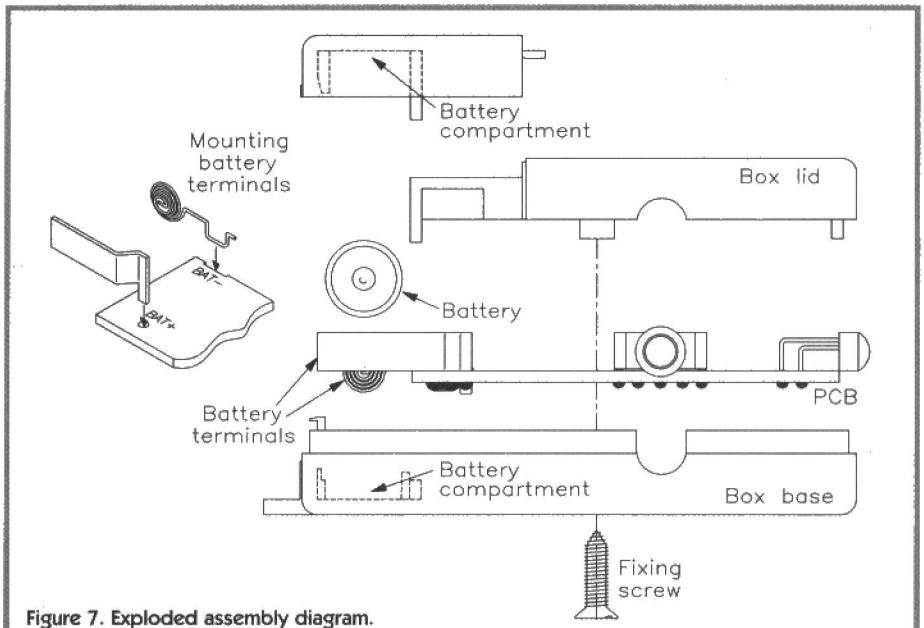


Figure 7. Exploded assembly diagram.

Testing

It must be pointed out that pre-electronic flash-guns will probably *not* work with this project, since they are intended to be triggered from a mechanical shutter which has very low resistance. The 'on' impedance of the opto-triac is probably too high to trigger such units.

There are a couple of simple tests that can be carried out, to see if your particular flash-gun is suitable.

First, set a multimeter to the highest DC voltage range (400V DC), and connect it to the flash-gun trigger contacts; switch 'on' the flash-gun (be careful, one flash-gun we tried charged up to +225V and discharged to −160V). Wait until the 'ready' light illuminates, then note the voltage; a desirable reading will be around the total battery supply voltage. Second, see if a 47 to 100Ω resistor will trigger the flash-gun.

Having built the Slave Flash Trigger and fitted it with a fresh battery, plug a 3·5mm MONO jack plug into the socket, which will switch the circuit on. Ensure that none of the components get suspiciously warm with the power on; switch off and recheck your assembly work if this occurs. Assuming all is well, the unit is ready to be tried out with a flash-gun, as follows.

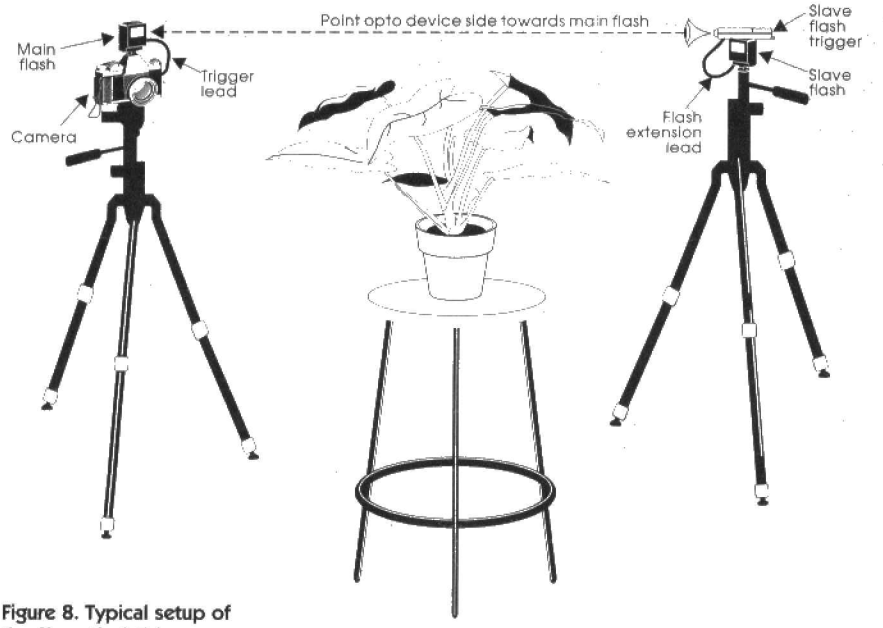
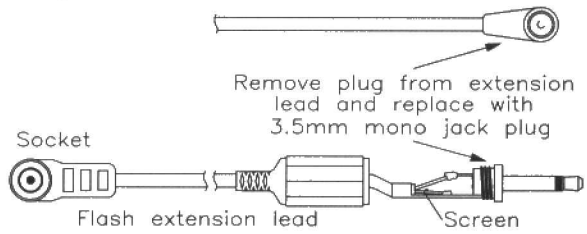


Figure 8. Typical setup of the Slave Flash Trigger

Figure 9. Lead modification diagram.



Use

Refer to Figure 8, showing a typical setup using the Slave Flash Trigger. Figure 9 shows the trigger lead modification required. Camera flash-guns are usually fitted with a 'hot shoe' connector, a trigger cable/socket, or both. Flash-gun trigger cables are usually fitted with a miniature coaxial plug. Some large flash-guns will be fitted with a miniature coaxial socket. Such connectors are not in common use for anything other than photographic applications, and for this reason, they are not available from Maplin; the best place to buy them is from a good photographic shop! Such shops will stock camera flash extension cables, fitted with a male coaxial connector at one end, and a female connector at the other end. Cut off the *unwanted* connector and fit a 3·5mm mono jack plug in its place.

If the flash-gun does not have a trigger cable or socket, a 'hot shoe adaptor' can be purchased from a photographic shop. The adaptor allows connection to be made to the flash-gun terminals that would normally connect to the camera when slid into the camera's 'hot shoe'. Such an adaptor will be fitted with a trigger cable or socket. Once the adaptor is fitted, proceed as if the flash-gun was originally fitted with a trigger cable or socket. It is possible that other connectors will be encountered, and in this case, it is best to refer to the flash-gun manual or seek advice from a good photographic shop.

With the Slave Flash Trigger connected to a suitable flash-gun, position the setup a reasonable distance from your main flash-gun within a room, and set it off! The slave unit should then flash in unison with the main flash. Blinding!

SLAVE FLASH TRIGGER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film			
R1,2	4k7	2	(M4K7)
R3	1M2	1	(M1M2)
R4	47k	1	(M47K)
R5	150Ω	1	(M150R)
R6	22Ω	1	(M22R)
CAPACITORS			
C1	22µF 16V Radial Electrolytic	1	(WW72P)
C2,3	10nF Ceramic Disc	2	(WX77J)
SEMICONDUCTORS			
D1	1N4148	1	(QL80B)
D2	1N4001	1	(QL73Q)
TR1	BC548	1	(QB73Q)
TR2	BC558	1	(QQ17T)
PT1	MEL12	1	(HQ61R)
OP1	Triac Optoisolator	1	(QQ10L)
MISCELLANEOUS			
SK1	3·5mm Stereo Jack Socket	1	(JM22Y)
	Keyring Remote Control Case	1	(JR90X)
	Front Panel Label	1	(95016)
	PCB	1	(95014)
	Instruction Leaflet	1	(XV86T)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
	GP23A 12V Photographic Battery	1	(ZB56L)
	3·5mm Mono Jack Plug	1	(HF80B)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.

Order As 95015 (Slave Flash Trigger) Price £9.99

The following new items (which are included in the kit) are also available separately, but are not shown in the 1996 Maplin Catalogue.

Slave Flash Trigger PCB **Order As 95014 Price £2.49**

Slave Flash Trigger Front Panel Label **Order As 95016 Price £1.99**

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Scanning Probe Technology

First Steps

More recently, a whole new area of development has been opened up by the development of scanning techniques which interact with surfaces at the atomic scale. The near-field scanning optical microscope (NSOM), while using light as the means of scanning, does so without any conventional lens systems. A fibre-optic cable with ultra-narrow tip emits light which is scattered/reflected from the material in the vicinity of the tip and is detected by an adjacent detector. This allows resolution of around 10nm to be achieved. These devices, however, are in the very early stages of their development. The resultant image would be established as the probe was scanned across a surface in reflection or in transmission mode. In transmission, such scanning probes can be used to detect the so-called 'evanescent' wave of light produced by total internal reflection, which travels parallel to the sample surface and is modulated by the presence of material in the sample being scanned.

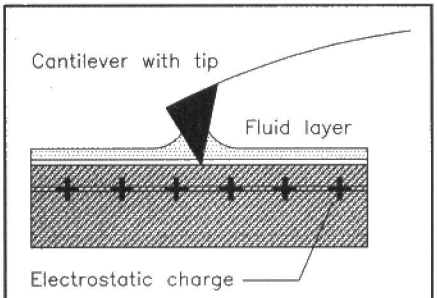

Figure 3. Surface fluid layer and electrostatic charges can pull down the scanning tip and distort the surface profile obtained. (Courtesy Digital Instruments, Santa Barbara.)

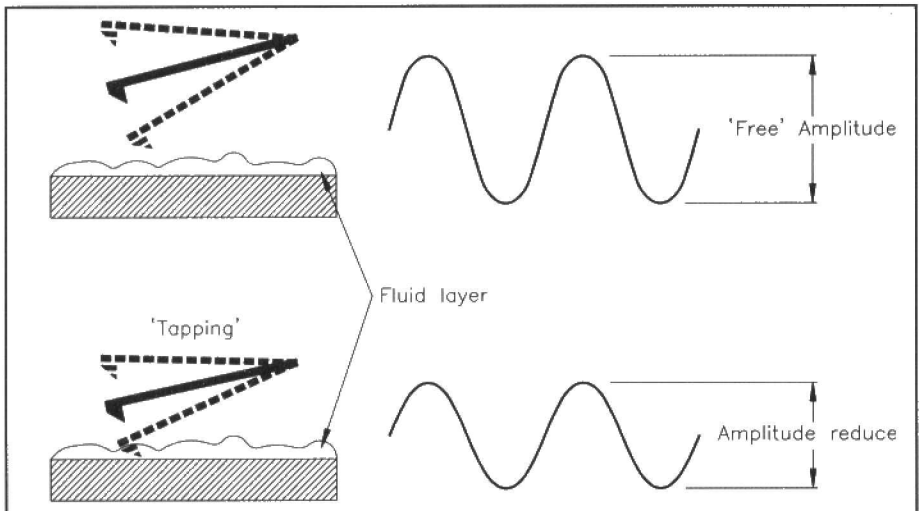

Figure 4. Principle of the TappingMode technology, where the probe system records the amplitude of oscillation of the tip above the sample surface. (Courtesy Digital Instruments, Santa Barbara.)

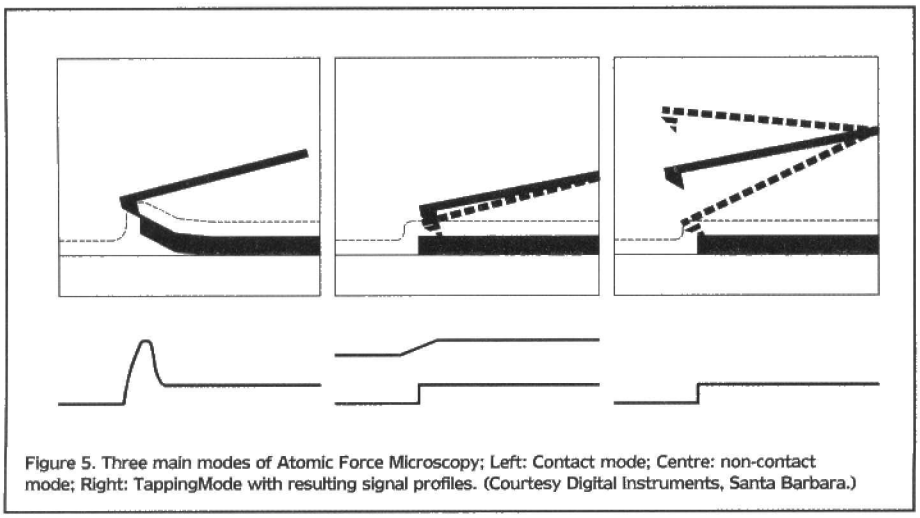

Figure 5. Three main modes of Atomic Force Microscopy; Left: Contact mode; Centre: non-contact mode; Right: TappingMode with resulting signal profiles. (Courtesy Digital Instruments, Santa Barbara.)

The first major advance with 'imaging' at the atomic level was the Scanning Tunnelling Microscope (STM), where a minute current flows as a probe tip is brought into the vicinity of an atomic surface. The current which flows increases sharply as the probe tip approaches the atoms of the surface being investigated. The mechanism of operation of the STM is not wholly understood, but it provides a ready tool with which to investigate a great number of surfaces. This 'imaging' technology is appropriate for surfaces which are moderately good conductors. Photo 4 shows the discoverers of the scanning tunnelling microscope, namely, Gerd Binnig (left) and Heinrich Rohrer (right) of IBM Research Laboratory at Zurich, Switzerland. The Nobel prize for Physics was awarded to the duo in 1986. Photo 5 shows the image of Silicon obtained using this scanning technique. Such images can be obtained with the minimum of surface preparation. The STM method, however, is only appropriate for samples which demonstrate good conductivity. Data from samples with low conductivity is more difficult to analyse objectively.

Atomic Force Microscopy

The range of options with Atomic Force Microscopy provides a more general means of detecting structure at the atomic scale. Most surfaces are contaminated by a layer of absorbed gas and surface moisture which tends to trap the tip of an Atomic Force probe tip. Also, electrostatic forces on the sample surface can distort the force experienced by the scanning tip. Such effects are indicated in Figure 3.

There are three basic methods utilised in Atomic Force Microscopy. One of the first developed was that of 'Contact' mode, where the probe tip was always in contact with the sample and could experience frictional and adhesive forces and in turn, damage samples and distort data. In non-contact mode, the probe tip is made to oscillate with a small amplitude above the sample surface. Van der Waals forces of attraction are measured by scanning the tip over the surface. This mode of detection is generally unsatisfactory, due to remaining problems of surface contamination and the weak value of the attractive forces. Improved resolution and general versatility has more recently been developed using TappingMode Imaging technology. In the TappingMode, indicated in Figure 4, the probe tip is oscillated at a frequency of between 50 and 500kHz, and is essentially free of the surface being investigated. As the probe tip is lowered towards the sample surface, it begins to contact the sample surface and atoms on its surface experience a discrete force with each contact. The amplitude with which this cantilever oscillates is reduced and the feedback system which maintains the amplitude of the oscillating force probe registers this change in amplitude. This in turn is used as a measure of the mean height of the probe above the sample surface. In this tapping mode, samples are significantly less stressed compared, for example, to a probe which is dragged over a surface. The control of the probe tip is undertaken by a piezoelectric drive system which can rapidly and accurately translate the probe tip to a required location. This type of technology has been extensively developed in optical/ laser alignment systems on optical benches.

The drive characteristics of such cantilever resonators enable surprisingly good resolution to be attained. With a 20V Pk-to-Pk drive signal and 1mV rms noise, a corresponding noise level of around 0·5 Angstrom (0·05nm) can be achieved.

Figure 5 indicates the signal profiles that would be anticipated with the three modes of Atomic Force Microscopy for a specific step feature. The contact mode is likely to 'stick' on the initial step. In non-contact mode, the signal can be influenced by surface contamination. In TappingMode, a more true set of measurements can be made. In this mode, measurements can also be made in fluids. A reduced range of resonant frequencies between 5 and 40kHz is typically used.

The tapping mode technology now allows scanning of material which would previously have been damaged by conventional

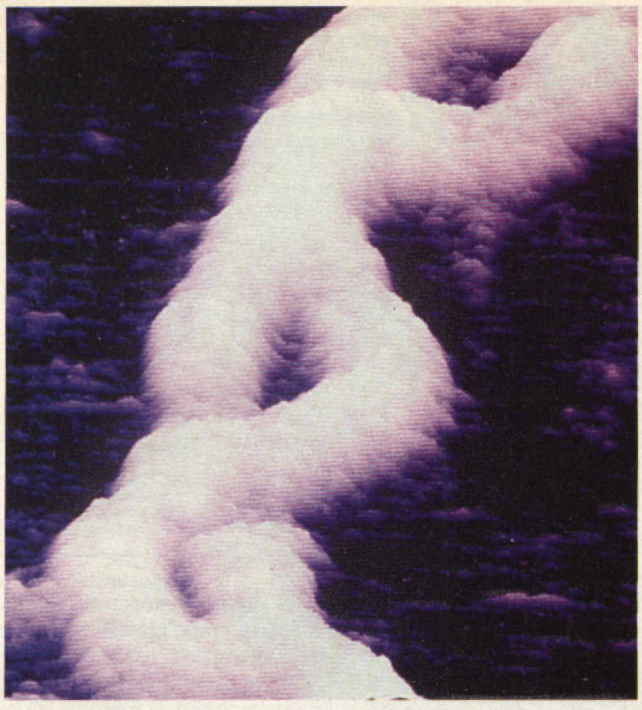

Photo 6. TappingMode image of double stranded DNA molecule imaged on mica: 155nm scan. (Image captured with Nanoscope Scanning Probe from Digital Instruments, Santa Barbara.)

Photo 7. Image of a 1μm scan of the surface of the epitaxial silicon layer grown on silicon. The surface is terraced because the substrate was miscut by 0·03° off the required plane. (Image captured with Nanoscope Scanning Probe from Digital Instruments, Santa Barbara.)

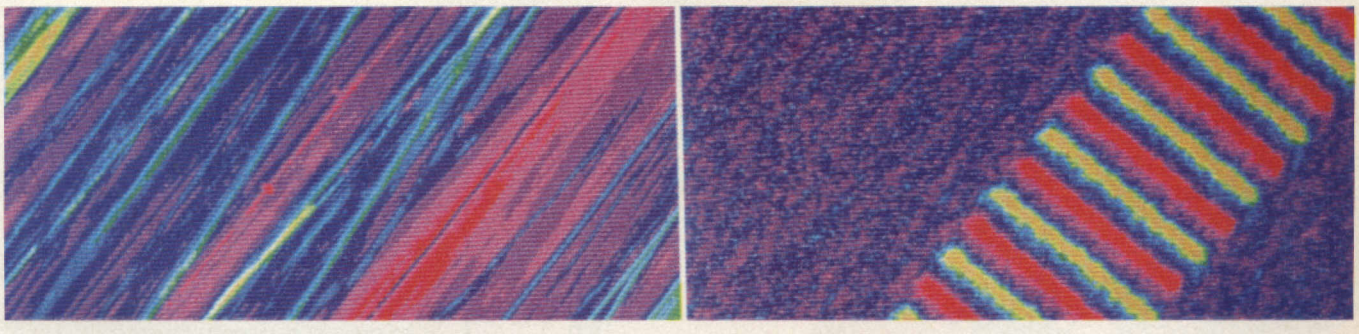

Photo 8. TappingMode image of the surface topography (left) and magnetic force gradient map taken with LiftMode (right) on a hard disk with 800 bit transitions per mm test track. Such analysis is used to verify the magnetisation pattern in relation to surface of the magnetic media (25μm scan). (Image captured with Nanoscope Scanning Probe from Digital Instruments, Santa Barbara.)

AFM techniques. Photo 6 shows the a double stranded DNA molecule imaged on mica, indicating the ability to resolve overlapping molecules. AFM has recently been demonstrated as a useful way of imaging and identifying bacteria, viruses and phages. Samples are typically air dried and coated with a carbon stabilising film.

Looking at Silicon

While integrated circuits produced in the 1980s utilised 2 micron wide channels and present devices utilise ones of 0·6μm, future circuits are likely to use 0·15μm technology. The high magnification required (especially for insulating materials) will be increasingly difficult to provide by means of scanning electron microscopes. The required level of magnification, however, is well within the scope of Scanning Probe Microscopy. Also, as levels of integration increase, the flatness of samples at every stage of fabrication will be of increasing importance. The SPM technology will be able to verify and monitor the effectiveness of the many complex processes of semiconductor manufacturing. In silicon wafer fabrication, a critical factor is the condition of the initial surface silicon prior to deposition and etching. Photo 7 indicates a 1μm scan of the surface of epitaxial layer grown on silicon. The surface is terraced because the substrate was miscut by 0·03° off the plane of symmetry of the substrate layer. Such technology provides a valuable means of validating quality standards in silicon wafer fabrication. It has been shown that continuous sampling using TappingMode of a 1μm element of silicon does not damage the surface profile.

Visualising Magnetic Fields and Magnetic Media

As magnetic storage capacities continue to be driven to new limits, scanning probe microscopy using specialised magnetic force gradient probes can provide valuable information about the data patterns on magnetic media and the associated relationship with topographic image of media surface. Photo 8 indicates a TappingMode image of the surface topography (left) and magnetic force gradient map, taken with LiftMode (right) on a hard disk with 800 bit transitions per mm test track. Comparisons of the two images indicate that the bit transitions are clear and sharp and without influence from the topography of the disk surface.

A similar study, this time for a Digital Audio Tape (DAT) is shown in Photo 9. A 10μm scan area is shown. The magnetic force gradients revealed on the right are resolved in the topographic image on the left. Such studies indicate that the minimum magnetic bit spacing in this sample is not limited by particle size. Photo 10 indicates the topographical image of a hard disk after a disk crash. The relative texture of the disk surface and the media at the crash site can be directly determined.

Visualising Electric Fields

Electrostatic force images of surfaces can provide information about surface connectivity. Photo 11 indicates details of an area of a failed GaAs device. On the left, a LiftMode topographic image reveals a metal trace with the suggestion of a failure along its track. When scanned under electrostatic force probe, a failure in the metallisation is readily observable – the scan size is 24μm. Such technology can therefore be used to 'see' the routing of voltage across a circuit. Often in microscopy, the problem is one of practicality – that of measuring samples in sufficient numbers and with sufficient speed to be able to provide useful feedback in

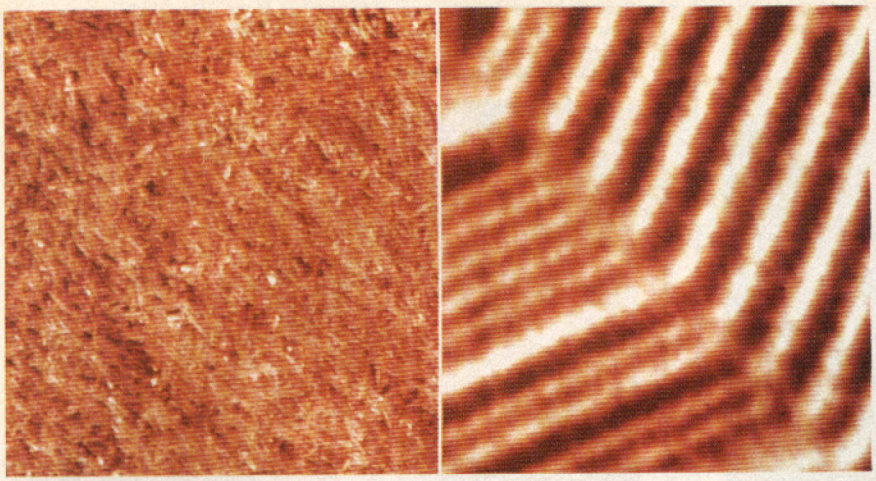

Photo 9. Scan of the topography and magnetisation pattern of Digital Audio Tape (10μm scan). (Image captured with Nanoscope Scanning Probe from Digital Instruments, Santa Barbara.)

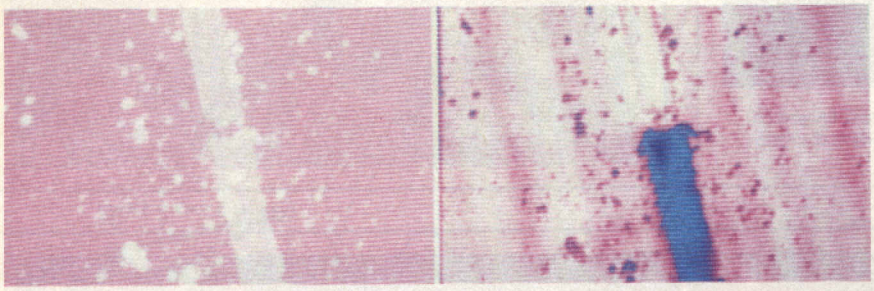

Photo 11. Details of an area of a failed GaAs device (24μm scan). Left: LiftMode topographic image reveals a metal trace with the suggestion of a failure along its track. Right: Electrostatic force probe reveals a failure in the metallisation. (Image captured with Nanoscope Scanning Probe from Digital Instruments, Santa Barbara.)

	Sample Destructive	Resolution
STM	No	High
Magnetic	No	High
Electric	No	High
Friction	Some	High
Atomic Force (contact)	Yes	High
Atomic Force (Trapping Mode)	No	High
Atomic Force (non-contact)	No	High

Table 2. Scanning Tunnel Microscope (STM) Parameter Comparisions

quality control in production and flexibility in research. The advantages of rapid sample preparation offered by Scanning Probe Microscopy over conventional methods such as electron microscopy is ensuring that such new techniques are gaining acceptance. Since the initial development of the STM, series of atomic scale probes have been developed to record a range of material characteristics as a function of three-dimensional spatial co-ordinates. These are summarised in Table 2.

Microscopy

The Future

While the age of optical microscopy is some 350 years old, that of Scanning Probe Microscopy is barely 10 years old. As new types of scanning probe tips are developed, so the opportunities to improve the understanding of basic science and develop whole new technologies in material science and semiconductor manufacturing are significantly enhanced. This will allow, perhaps, the solution of some stubborn 'old' problems in science, and a more rapid resolution of more recent scientific conflicts.

The emerging Nanotechnology will be well served by Scanning Probe Microscopy. It has even been demonstrated that atoms can be moved by direct probe action on them – witness the IBM logo produced by moving Xenon atoms on a substrate. This type of technology (a type of nano-fabrication) may emerge as a useful tool in the future. The importance of the microscope is being rediscovered in UK education. The Royal Microscopical Society has recently launched the 'Microscope in Every School' initiative to try and give as many school children as possible the opportunity to learn at first hand, the delights of the microscope. E

Photo 10. Topographical image of a hard disk after a disk crash (1μm scan). (Image captured with Nanoscope Scanning Probe from Digital Instruments, Santa Barbara.)

Points of Contact

Royal Microscopical Society,
27-38 St. Clements, Oxford, OX4 1AJ.
Tel: (01865) 248768, Fax: (01865) 791237.

Microscopy in Analysis, published bimonthly by Rolston Gordon Communications,
1 Gable Cottage, Post House Lane,
Bookham, Surrey, KT23 3EA.
Tel: (01372) 454891, Fax: (01372) 459957.

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3
PROJECT RATING

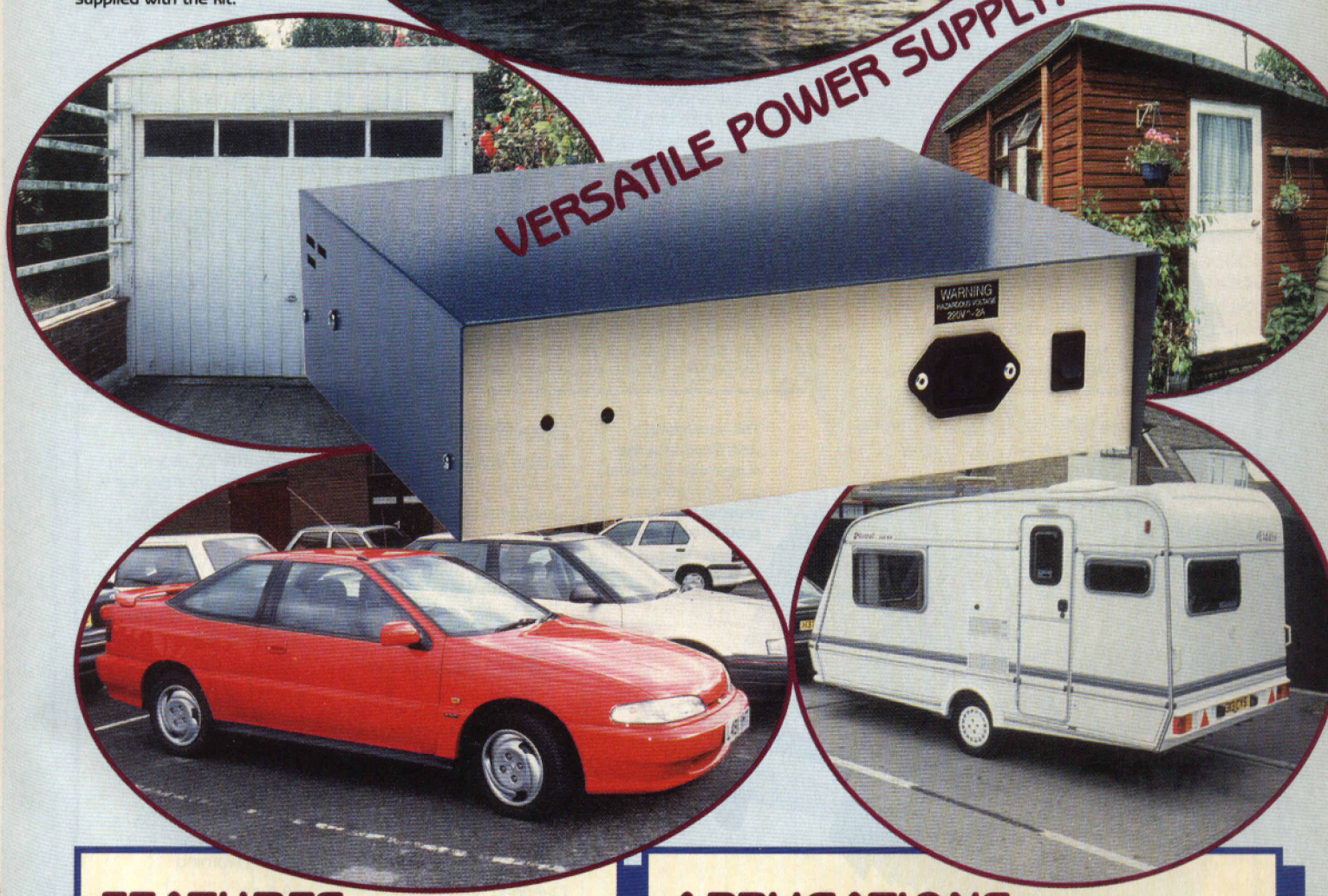
KIT AVAILABLE (95013) PRICE £49.99 B1

12/24V to 220V INVERTER

Additional items supplied with the kit to improve safety, are shown in the Supplementary Miscellaneous Parts List. All the following information supersedes the original leaflet supplied with the kit.

Text by Maurice Hunt and Mike Holmes

VERSATILE POWER SUPPLY!



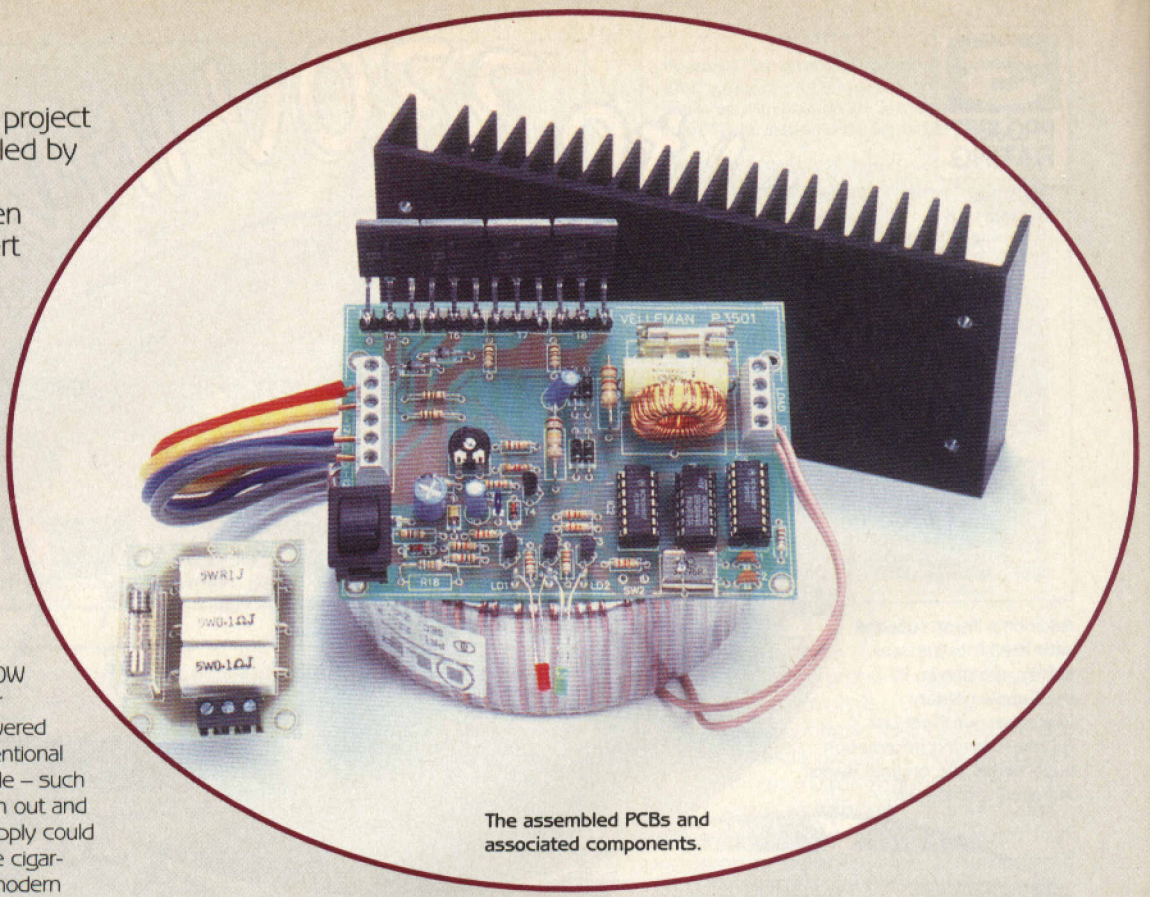
FEATURES

* Automatic overload protection
* Easy to build and use
* Rugged design * Compact
* Quiet in operation

APPLICATIONS

* Camping and caravanning
* Outdoor events
* Mobile repair and maintenance work
* Mains power cut emergency back-up

Build this superb Inverter project and never again be troubled by a lack of mains power, wherever you may happen to be. This unit will convert the 12 or 24V DC supply from a car or truck battery, or similar power source, into a mains level AC supply, which is adjustable across the range stated in the Specification table.



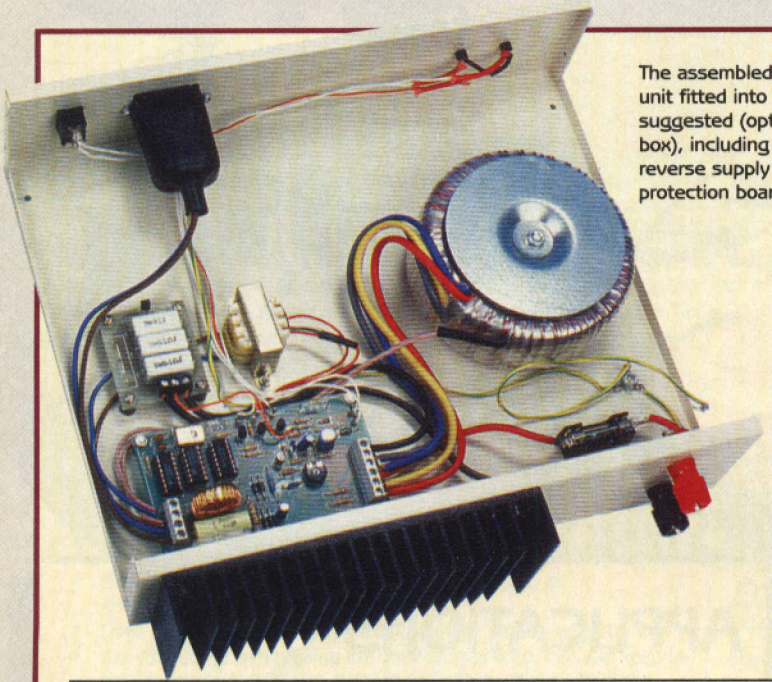
The assembled PCBs and associated components.

THIS versatile inverter unit is capable of running mains appliances of up to 300W rating from a 24V supply, and 160W from a 12V supply, and is ideal for many situations where mains powered equipment is needed but a conventional mains power supply is not available – such as in the middle of a field, or when out and about in a vehicle (the 12/24V supply could be obtained conveniently from the cigar-lighter socket standard on most modern vehicles). Ideal for many applications that would otherwise have required the use of a noisy, bulky and expensive fuel-burning generator. The convenience and portability of this project make it essential equipment for camping, caravanning, outdoor events and promotions, use in non-electrified garages and outbuildings, or as standby/ emergency equipment in the event of a power cut. It will enable you to operate many electrical and electronic appliances, from lamps and shavers, to video recorders and TV sets.

Another use for the unit would be for ascertaining whether or not mains-powered electrical appliances that are being sold at car boot fairs, jumble sales, junk shops and the like actually work, so that you can strike the best deal, favourable to whether you happen to be buying or selling! You could also do on-the-spot repairs, operating a soldering iron, inspection lamp, power tools, etc., even with no mains supply in sight, which will impress observers no end.

The project has so many potential uses in fact, that you really cannot afford to be without one!

Other features of the Inverter include a low input voltage cut-off threshold, to prevent the input source, if it is a battery, from being completely drained. The circuit will automatically drop out when the input voltage drops below 16V with a 24V battery, or below 9V with a 12V battery. Overload protection is also provided, in the



The assembled unit fitted into the suggested (optional box), including the reverse supply protection board.

Specification

Supply voltage:	12 or 24V DC from car/ truck battery or similar
Quiescent supply current:	0·25A @ 24V input 0·5A @ 12V input
Output voltage (adjustable):	167 to 281V* AC rms (no load)
	143 to 208V* AC rms (100W lamp)
Maximum output power:	300W @ 24V input
	160W @ 12V input
Output AC frequency:	50Hz
Output voltage stability:	±10%
Efficiency:	>90%
Visual indicators:	Red and green LEDs for power on and low battery warning
Overload protection:	2A fuse

SAFETY WARNING. The Inverter unit is designed to supply a high voltage AC output voltage, at mains level, and is thus capable of delivering the same potentially lethal electric shocks as the mains supply. Therefore, the same safety precautions that apply to mains equipment must also be taken when using this unit. Always switch off the unit before carrying out any maintenance or adjustments, and do not operate the unit with the casing lid removed, or in damp conditions. It is beneficial to use an RCD, wherever possible the earthing point should be connected to the physical mass of earth. Note that the unit is only suitable for use with isolated or negative-earth supplies – DO NOT operate the unit from a positive-earthed supply.

*The voltage levels stated will be approximately 10% above the actual rms voltage, since the voltage output of the Inverter is not in the form of a pure sine-wave, and hence, a conventional multimeter reading will be higher than the real value. The effective output voltage will thus be approximately 220V AC rms with the unit correctly adjusted.

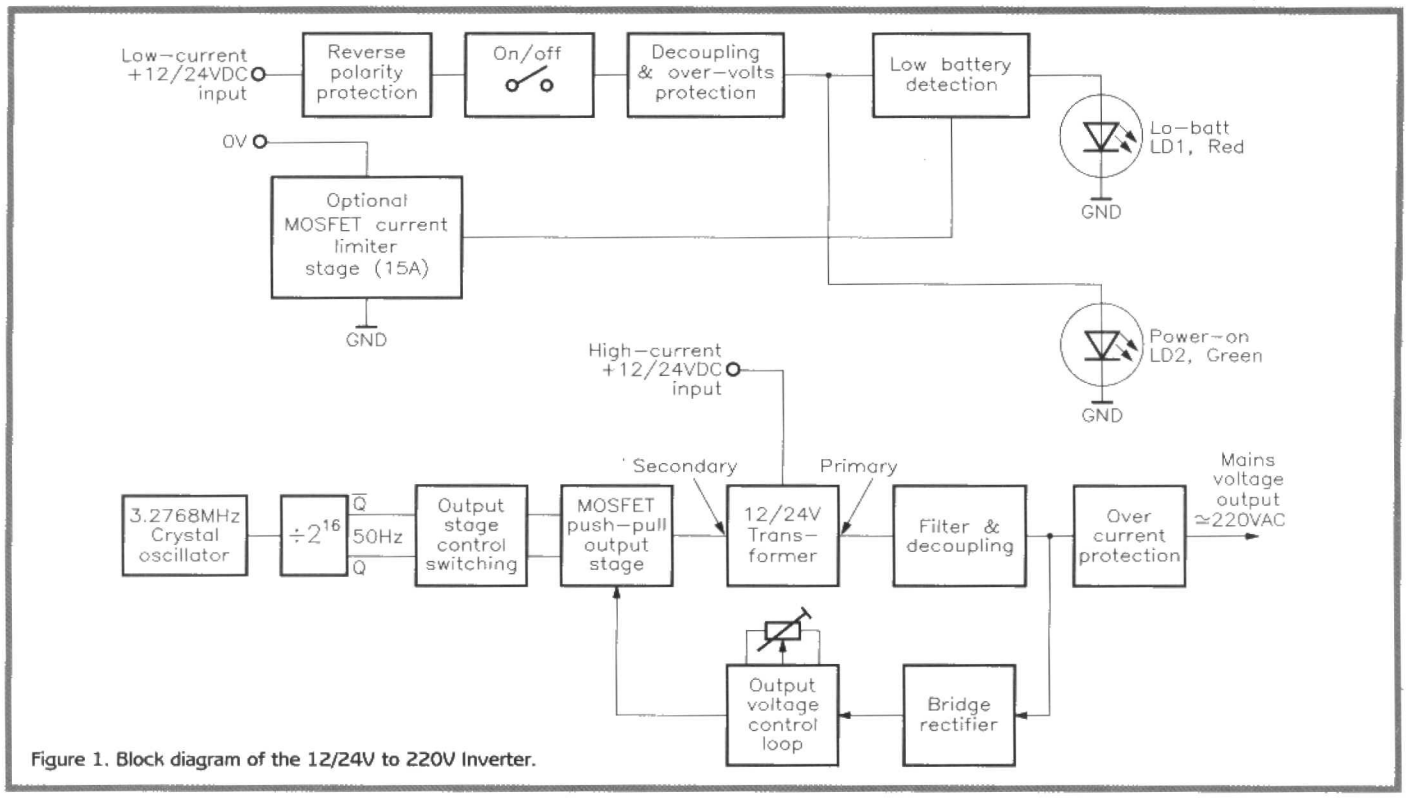


Figure 1. Block diagram of the 12/24V to 220V Inverter.

form of a 2A time-delay fuse on the main PCB, 15A fast acting fuse on the low-voltage input, and an (optionally fitted, but supplied in the kit) MOSFET current limiting PCB. This latter part of the circuit also provides an automatic reset circuit, whereas if you do not wish to fit this extra board, a manual reset switch will be required.

Circuit Description

The block and circuit diagrams of the Mains Inverter are shown in Figures 1 and 2, respectively. The choice of toroidal transformer chosen for the project determines whether the unit will convert 12 or 24V sources to a 220V AC supply.

The object of the circuit is to drive a step-up transformer (TF1) from the 12 or 24V DC supply, producing an AC output with a voltage and frequency equivalent to the domestic mains supply. Although a switching waveform is used, as opposed to a true sinusoidal waveform like the mains supply is supposed to consist of, the on-time of each half cycle is limited, such that the waveform has the same power content as an equivalent sine wave with the same equal peak voltage.

An accurate crystal timebase is used to derive the 50Hz output frequency, with crystal X1 and associated components completing the internal oscillator of IC1. IC1 is a 14-stage ripple counter, dividing the frequency of X1 by 16,384, reducing the crystal's 3·2768MHz to 200Hz. This goes through two further stages of divide by two, until the last stage of IC3 (a dual flip-flop), which directly drives the MOSFET output

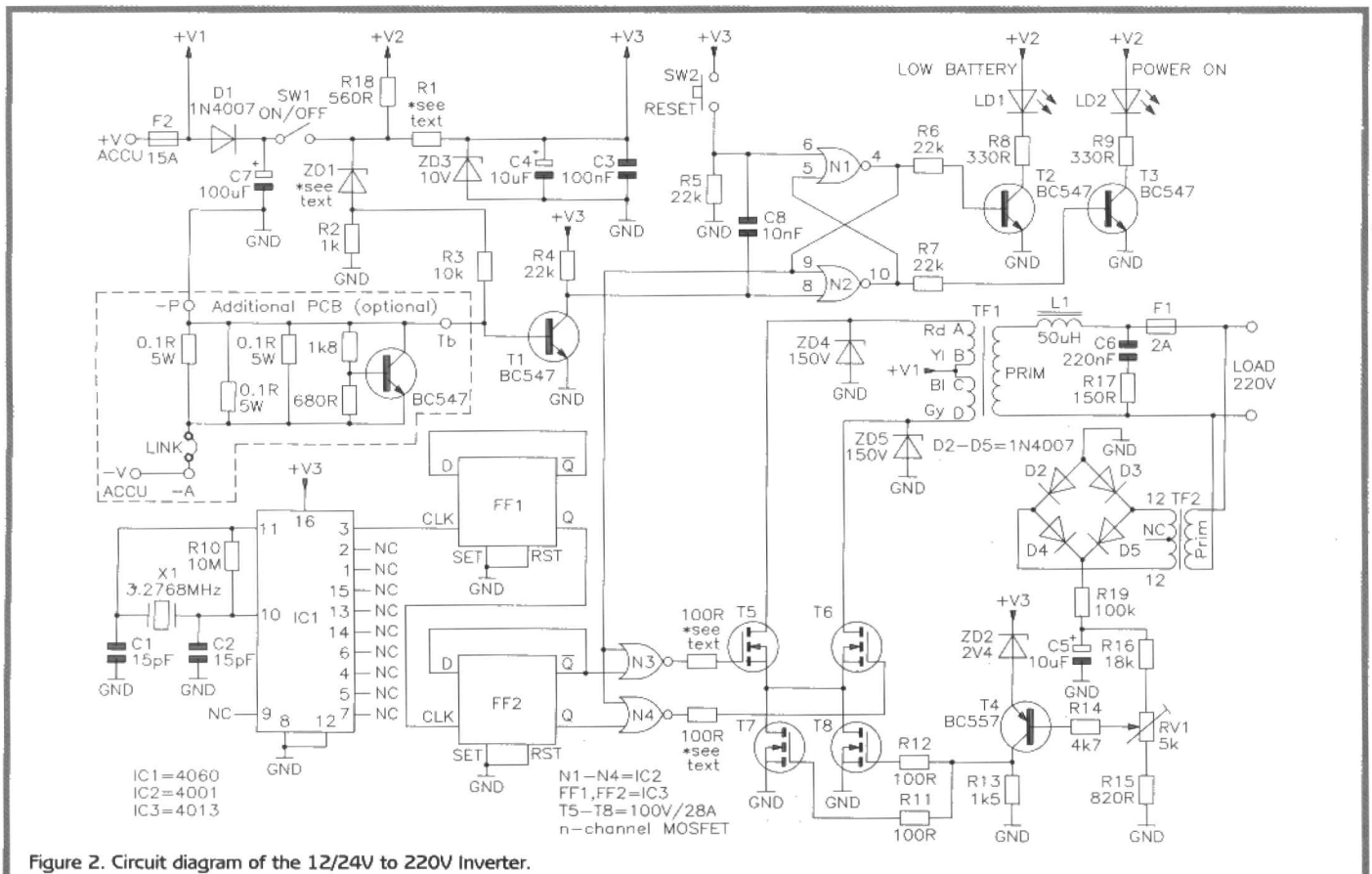
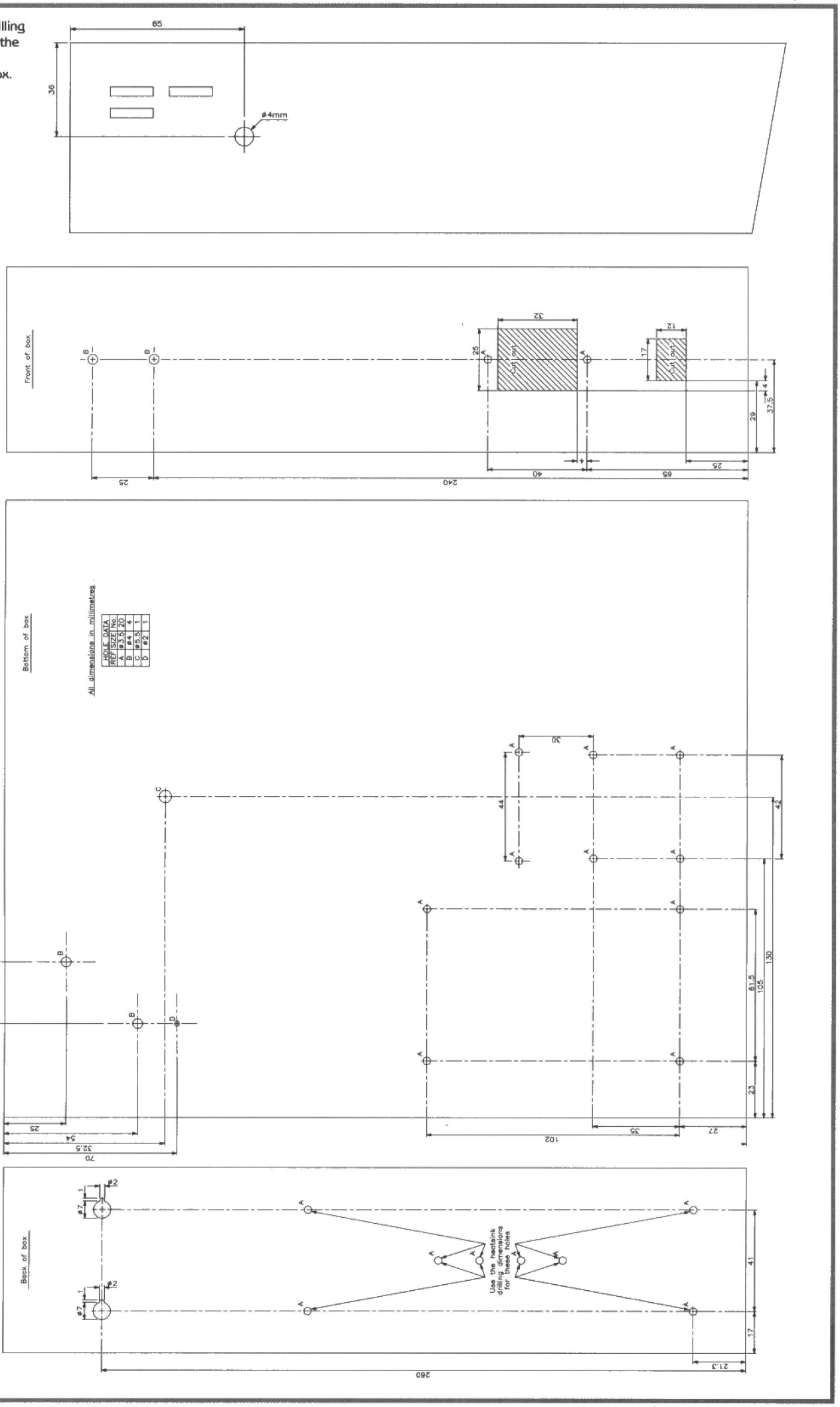


Figure 2. Circuit diagram of the 12/24V to 220V Inverter.

Figure 3. Drilling diagram for the suggested (optional) box.



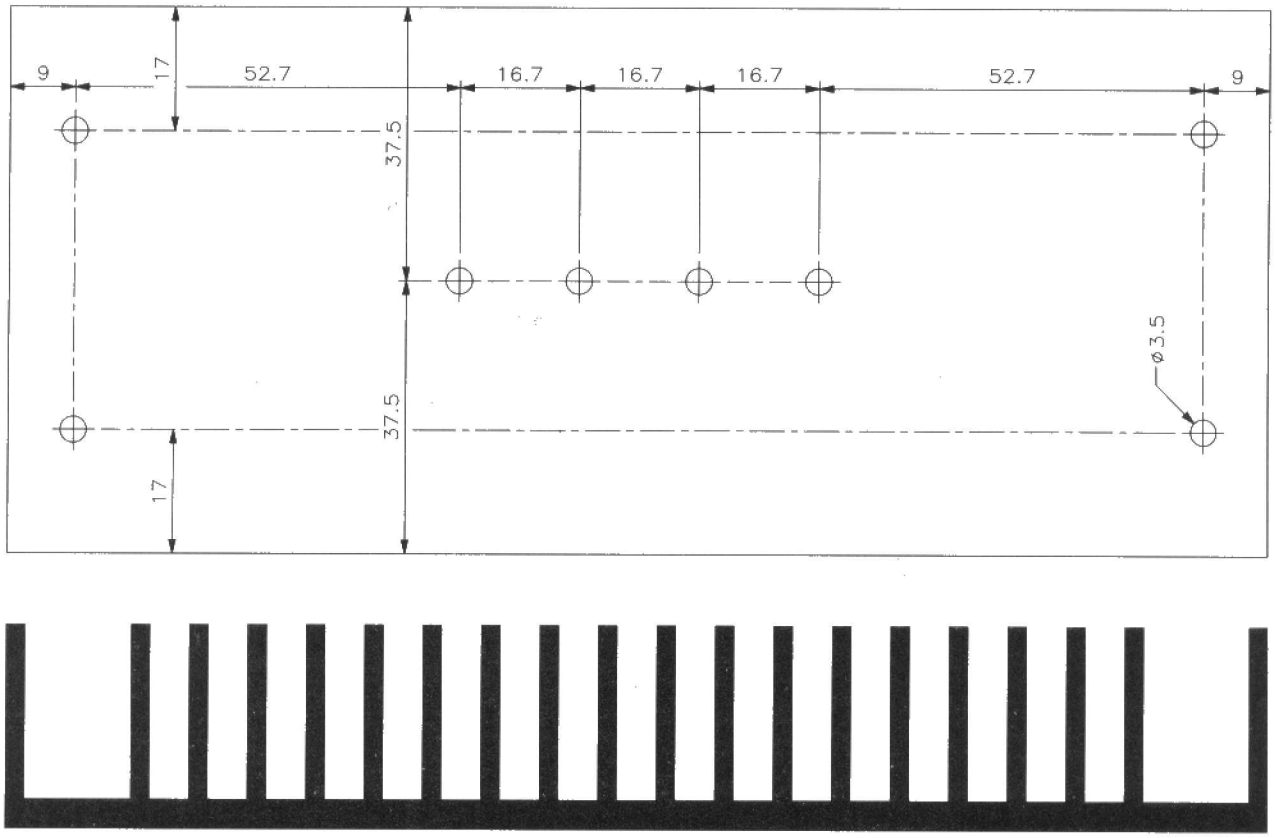


Figure 4. Heatsink drilling diagram.

switches, T5 and T6, on alternate half cycles of the waveform from noninverted and inverted outputs of FF2.

Regulation of the output voltage is very simple. Normally, T7 and T8 are held in the 'on' state by T4, whose base is forward biased from 'GND' via R14, RV1 and R15. The output is rectified through D2 to D5 and appears as DC across C5, also acting as a filter with R19. The resulting voltage is divided by the chain R16, RV1 and R15, and a proportion is tapped off by RV1 to the base of T4. When the level at this point exceeds the combined voltage drop set by ZD2 and the base/emitter forward drop, T4 turns off, also turning off both T7 and T8, and the TF1 transformer secondary voltage falls to zero. By the time FF2 changes state and begins the opposite half cycle, T4 is ready to turn on again due to the falling voltage across C5.

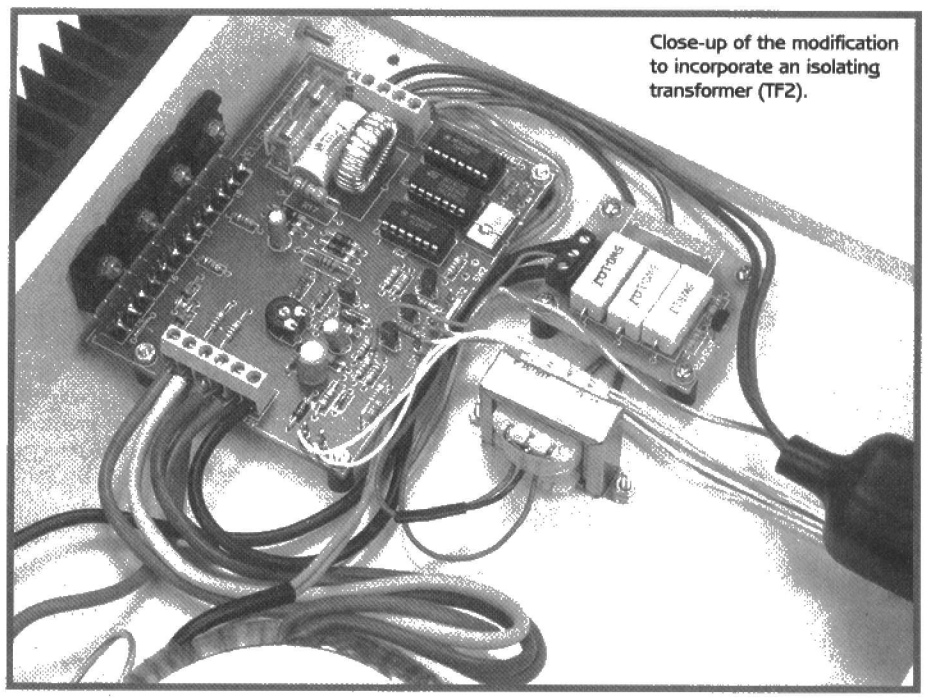
DC Power for the unit enters at '+V ACCU' (battery positive) and '−V ACCU' (battery negative). Diode D1 prevents accidental damage to the control circuitry in the event of reversed polarity connection, and SW1 is the main on/off switch. R1, ZD3, C4 and C5 provide a stepped-down supply for the control logic stages.

Visual indicators in the form of two front panel LEDs, are driven by the bistable N1, N2 and driver transistors T2 and T3. Normally, the bistable is set with N2 output (pin 10) high, switching on T3 and the red LED, LD2 ('POWER ON'). This holds N1 output (pin 4) low. If the battery voltage drops too low, ZD1 will no longer be able to support base bias for T1; this causes T1 collector to go high and force N2 to logic 0 state. The bistable changes state turning off LD2, and turning on the green LED, LD1 ('LOW BATTERY'). At the same time, it defeats T5 and T6 by applying a logic 1 to gates N3 and N4, halting any further output. Transformer TF2 is included to isolate the low-voltage input from the high-voltage output, to prevent any risk of shocks occurring when connecting the low-voltage supply to the input terminals.

The output is short-circuit and overload protected by fuse F1. Additionally, a 15A fuse (F2) is provided on the positive side of the low-voltage input, providing overload protection in the event of a fault developing within the unit. The over-current protection PCB includes 5W dropper resistors in series with the negative battery supply. These three resistors are all 0·1 in value, therefore, the total voltage drop across these at 15A is 0·5V. For short-term current surges, the BC547 transistor clamp is turned on, switching off T1 and initialising a low battery shutdown.

PCB Construction

Assemble the main and additional PCB (if required) in order of ascending component size, from smallest to largest. Initially, two of the tracks on the main PCB need to be cut in the positions indicated in the inset diagram on Figures 7 and 8, these being between the junction of D3/D5 and the F1 fuseholder, and between the junction of D2/D4 and R17, in each case, leaving a gap of at least 5mm; this is to allow the



Close-up of the modification to incorporate an isolating transformer (TF2).

inclusion of an extra transformer (TF2), for isolation of the output from the input.

Commence assembly with the two wire links (marked 'J' on the board); use either component lead offcuts or preferably, tinned copper wire for these. There should also be a thick wire link across the original F2 position on the additional PCB (marked '16A SLOW' on the legend) – this fuse has been relocated to a separate fuseholder fitted elsewhere within the casing. Ensure that resistors of the correct power rating are fitted where specified. Note that the resistors R16 and R19 as supplied in the kit are discarded, and are replaced by higher rated (0·6W) resistors of different values; this change is required as a result of including the extra isolation transformer, TF2.

Note also that resistors R17 and R18 should be fitted at a height of approximately 5mm above the surface of the board, since these parts are likely to get warm during prolonged use. Observe the correct polarity of the semiconductors and electrolytic capacitors. The crystal should be fitted with its body flat to the board, and a length of offcut lead from a component (or tinned copper wire) should be soldered across its body and into the holes provided on the PCB adjacent to the crystal. Use PCB pins for the LD1, LD2, +V2, SW1, and SW2 (if required) terminals.

Continued on page 39.

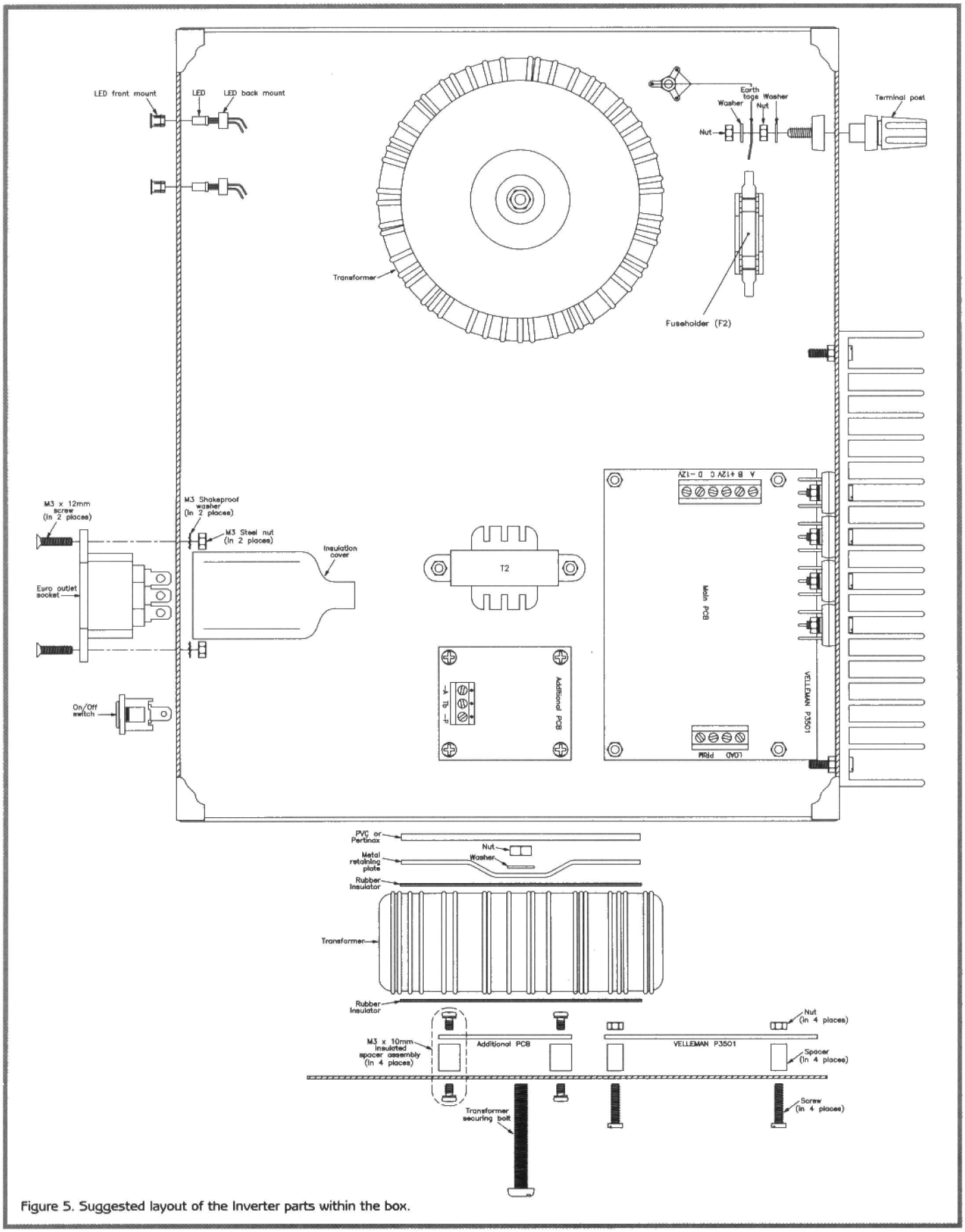


Figure 5. Suggested layout of the Inverter parts within the box.

The INTERNET PART 3

The World Wide Web

The World Wide Web (WWW) is the rock and roll of the Internet. A place where video images meet interactive text and sound. But what lies behind the media hype? Is the WWW a children's playground, or is it actually a useful communication tool? Stephen Waddington examines the structure of the WWW, how it can be accessed, and some of the best places to surf.

In the Beginning

The World Wide Web (WWW) began life as a project at the European Laboratory for Particle Physics (CERN) in Geneva, Switzerland. Researchers at CERN wanted to develop a multilayer document which students could navigate their way through. Rather than including copies of referenced papers or definitions of complex terms within the body of a main document, they devised hypertext – a system which enables distributed documents to be drawn together in a single source document.

Help files within Windows are an example of hypertext documents, though their functionality is limited in comparison to the WWW. If while you are browsing through a help page, you want additional information about a highlighted topic, you can simply click on it, and information about the new topic is retrieved. The new information will almost certainly be retrieved locally from within the confines of your machine. But this need not be the case. In a future incarnation, the help file for Word might call-up Microsoft's server in the US, to retrieve data relevant to a particular problem.

Hypertext enables documents by different authors to be linked together from different sources. In this manner, a hypertext document operates at two levels, as illustrated in Figure 1. The first level displays the visual images which the viewer is able to observe. Below this lies the hypertext level containing the addressing information necessary to carry a viewer from one document to another.

Formal Definition

The World Wide Web is a library of hypertext documents which lies on computers linked by a massive internetwork. Having retrieved a document, a viewer is able to move to other documents by clicking a mouse on highlighted words.

For example, if you are interested in the PowerPC, you can load up the PowerPC WWW site, accessible from the home page of any of the alliance partners – Apple, Motorola or IBM, as shown in Figure 2. But perhaps you want to know about PowerPC hardware vendors rather than aspects of the PowerPC technology. If so, click on System Vendors from the home page and you'll be linked to a list of manufacturers which have developed PowerPC hardware. From here, you can click on any of the company names offered to view individual company's PowerPC product offering.

Accessing the World Wide Web

To access the WWW, you need Internet access and a WWW browser client. The WWW browser sits on top of the Internet as shown in Figure 3, and displays information accessed from the Internet (in this model, the server) at the demand of the user. Since CompuServe led the way at the beginning of 1995, Internet providers have lined up to supply full Internet access, as illustrated in Table 1. Increasingly, these providers are cutting costs and simplifying Internet access mechanisms in a bid to attract users. For example, CompuServe has introduced an Internet dialler for its account holders. This dials directly into the Internet when a WWW browser is loaded, as shown in Figure 4. Meanwhile, Pipex offers its account holders

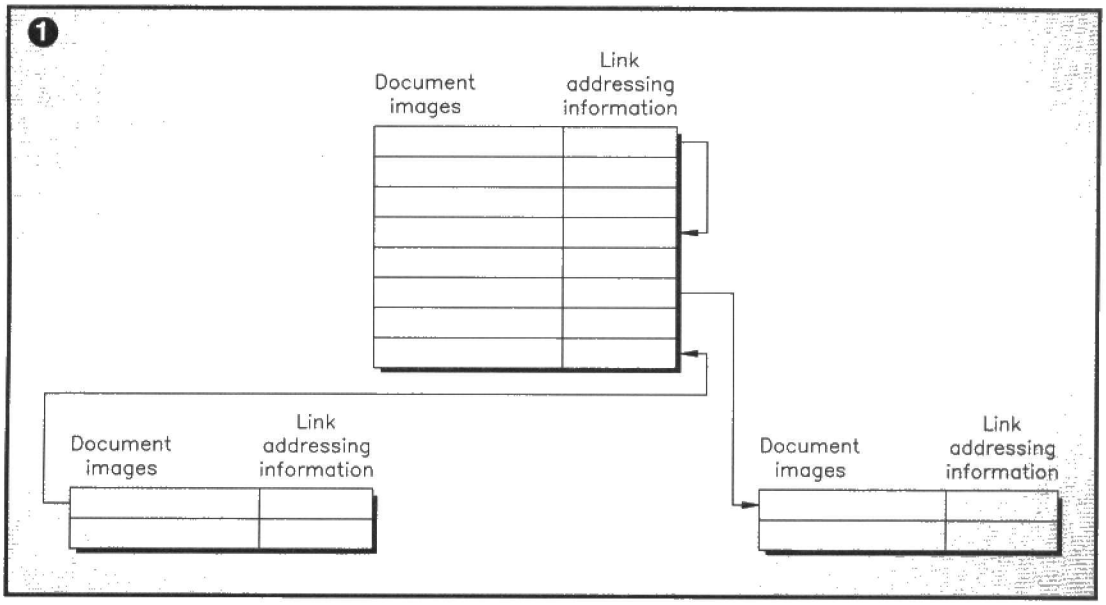
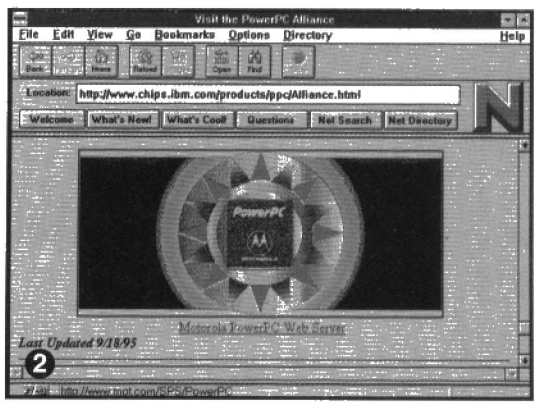


Figure 1. Hypertext documents operate at two layers. The document layer contains the actual text visible to the reader. The Link Addressing Information provides hyper links to connected images. Note that this information need not be contained within the same document, and can be retrieved from a different location.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Welcome What's New! What's Cool! Questions Net Search Net Directory
PowerPC
Motorola PowerPC Web Server
Last Updated 9/18/95
2

Figure 2. The PowerPC home page (http://www.powerpc.com), accessible via hyperlinks from the WWW site of any of the PowerPC alliance partners.

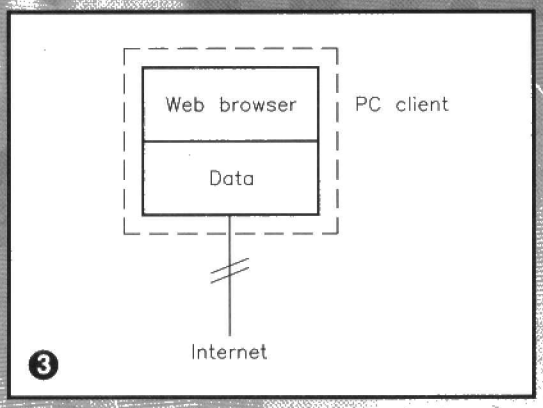


Figure 3. The WWW Browser sits on the client PC, and displays information retrieved from the client source, in this case, a remote WWW server linked to the Internet.

Figure 4. Internet users with CompuServe accounts are able to use the CompuServe Internet dialler to gain WWW access.

Internet Provider	Contact Number
CityScape Internet Services	(01223) 566950
Compulink Information eXchange (CIX)	(0181) 390 8446
CompuServe Information Service	(01734) 391064
Delphi Internet	(0171) 757 7080
Demon Internet	(0181) 349 0063
PIPEX (Public IP Exchange)	(01223) 250120

Table 1. Companies able to provide Internet access.

WWW access as an option alongside e-mail from within its integrated Pipex Dial suite.

Whichever Internet service provider you select is irrelevant once online. At this point, it is the browser that becomes the client front end, enabling documents to be read and fetched from servers across the world. Browsers allow both the multilayered aspect of hypertext documents and the interface to the Internet to be handled transparently to the user. There are a variety of browser packages available. Top of the pile are Netscape and Mosaic for both Windows and the Apple Macintosh. But the list does not end here, text-based browsers, popular during the eighties when the Internet was broadly an Academic system remain popular, and Unix clients are still widely used.

Lynx

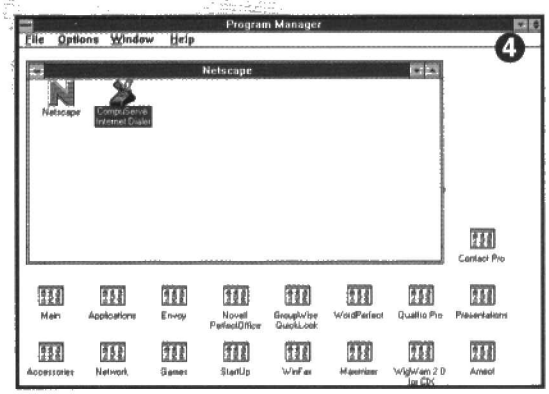
The most widely used text based browser is probably Lynx. Developed at the University of Kansas and originally for Unix systems, the program has also been ported to the MS-DOS environment. DosLynx will run on a PC with 512K-bytes of RAM, running MS-DOS 3.0 or above. It is the simplest WWW browser available, providing WWW access to the most basic PC equipped with an appropriate Internet access. Lynx browser software for Unix is available at **ftp://src.doc.ic.ac.uk/packages/www/lynx**, alternatively, DosLynx is available at **ftp://ftp2.cc.ukans.edu/pub/www/doslynx/**

NSCA Mosaic

NSCA Mosaic for Windows and the Macintosh helped to popularise the WWW by making both its text and more importantly, graphical functionality, available to the personal computing masses. The graphical format simplifies WWW access, and provides a number of utilities to aid WWW access. Users are able keep bookmarks of favourite WWW sites, and navigate backwards and forwards across the WWW using simplified buttons. NSCA Mosaic browser software for Unix, Windows and Apple Macintosh platforms is available at **ftp://src.doc.ic.ac.uk/packages/www/mosaic/**

Netscape

Netscape Communication (see Figure 5) was established by Jim Clark, founder of Silicon Graphics and NSCA Mosaic creator, Marc Andreessen. In fact, Clark recruited a number of the development team from Mosaic to help develop a browser, which would provide faster WWW access than the Mosaic package. This was achieved with the first version of Netscape, which displays images incrementally, allowing images to be scanned and read by the user while they are being loaded. Consequently, this is the best browser for individuals who access the WWW via a modem, since it is possible to move from one document to another without a particular document being fully loaded. Netscape is a commercial product, but at the time of writing, was still being offered for unlimited evaluation by private users. The browser is available in a variety of PC and Macintosh formats from **ftp://ftp.mcom.com** in the Netscape subdirectory, as shown in Figure 6.



There are number of alternative browsers in use, and others that are being developed by companies such as IBM, Microsoft, Apple and Novell. In the future, browsers are likely to gain richer features, perhaps incorporating powerful search facilities, and mechanisms to handle both sound and moving images.

At present, the most popular browser is undoubtedly Netscape. Netscape is so hot that when the 18-month old company floated last August, it's stock valuation was US$140 million. Figures published in September by Yahoo, a WWW search engine, show that of 41,910 WWW users accessing during a 14 day period, 33,010, or 78·8%, were made by individuals using a Netscape client. As Figure 7 shows, only 7·5% of accesses were made by a Mosaic browser, and 4·7% by Lynx. Other browser packages ranked second in a top four listing with 3,770 accesses, representing 9·0%.

Figure 5. The Netscape WWW browser.

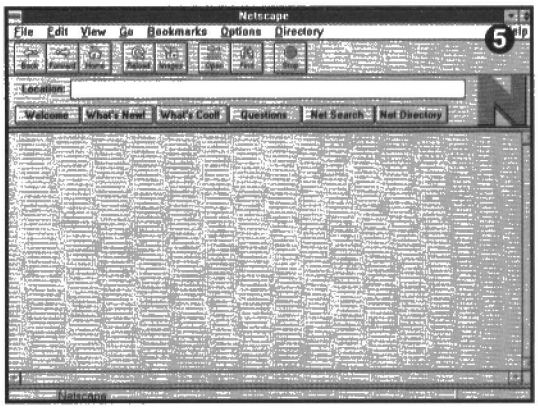
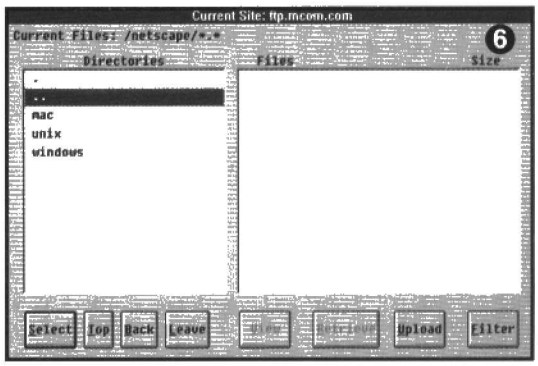

Netscape
File Edit View Go Bookmarks Options Directory
Location
Welcome What's New! What's Cool! Questions Net Search Net Directory
5

Figure 6. The Netscape browser can be downloaded in a variety of formats using ftp.



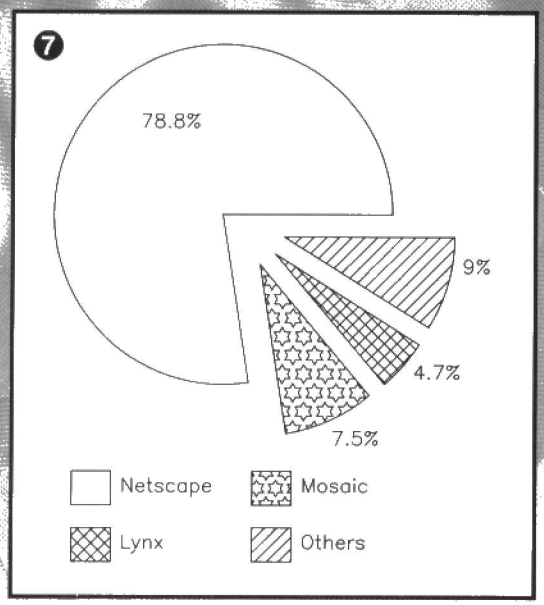


Figure 7. Pie chart showing the popularity of a variety of WWW browsers.

WWW Addressing

The address of a WWW site is known as a Universal Resource Locator (URL). Typically an address takes the form: *access method://address/document*

The first part of the URL before the colon, specifies the access method: ftp for FTP access, http for hypertext documents. The part of the URL after the colon is the WWW site address, unique to a particular site or WWW page. The final item in the URL is the document name or name of the WWW page. Entering the URL at the browser command line will enable you to immediately access a WWW site of your choice. WWW addresses are published extensively throughout the media, and companies are beginning to publish their URL on corporate literature, ranging from advertisements through to business cards.

But what if you want to access a WWW site but are unsure of the appropriate URL prompt? In this case, there are a couple of options: either access a WWW search engine or call-up a virtual library of WWW sites. Unfortunately, there is no single catalogue of WWW sites, instead, a series of libraries record appropriate lists of WWW URL addresses submitted to the library.

The World Wide Web virtual library (**http://www.w3.org/pub/datasources/bysubject/overview.html**) as shown in Figure 8, is the oldest library managed by the W3 consortium, which strives to promote the interoperability between WWW products. The consortium is headed by the University of Massachusetts, reflected by the library which is heavily education-based. The site does not actually contain any information except links to thousands of other sites. Information is sorted (and can be searched) in subject order, and consequently, is useful if you are tracking down information about a particular theme.

Beyond searching out particular subjects, the scope of a virtual library is limited. If you are looking for a particular company or educational WWW site but do not know the URL, a search engine is probably the most appropriate mechanism to enable you to reach your intended destination. There are a host of competing search tools (see Figure 9), which typically scan lists of WWW addresses for your key word. Again, as with virtual libraries, each of the search engines is only as good as the list of WWW site which it manipulates. Search engines are reliant on creators of new WWW pages submitting their new details so that they may be included in the search engine. There are several search engines available. A selection is detailed here, alongside their URL:

- Spry Internet Wizard (**http://www.compuserve.com/wizard/wizard.html**) This search engine, provided on CompuServe's WWW site, takes your keywords and returns the 20 top matching WWW sites. An adjacent page provides links to other search tools.
- World Wide Web Worm (**http://www.cs.colorado.edu/home/mcbryan/wwww.html**) This engine lets you search for WWW pages by locating page titles or words within the URL address.
- NetMall (**http://www.ais.net:80/netmall**) American Information Systems' database is designed to help you locate companies large and small which maintain a WWW presence, ranging from Microsoft to tiny mail order shops. The benefit of this service lies in the fact that it has a pure business focus.
- Yahoo (**http://www.yahoo.com**) This service searches a listing of WWW site descriptions, and will rarely return less than twenty hits, regardless of the string submitted. Unfortunately, the results do not tell you an awful lot about each of the sites, since Yahoo's abstracts are brief comments.

Bookmarks and Browsing Robots

If you spend any length of time browsing the WWW, you will quickly build up a list of favourite places. These can be stored as bookmarks within your browser. There are pages which you may access on a daily basis because of their news content, or perhaps you want to scan a manufacturer's WWW site for details of new products occasionally. It does not matter where you are, or what time of day you access the WWW. Part of its beauty is the fact that information is delivered to you on demand.

However, rather than scanning your favourite pages every time you go online, you can use a WWW browsing robot which will notify you every time a WWW page of interest to you has been updated. At the moment, NetMind is the only organisation providing this service. By accessing the NetMind's URL-minder WWW site at **http://www.netmind.com/url-minder**, as shown in Figure 10, Internet users can register pages of interest. A Web Robot will monitor this page and e-mail you every time something new is added to the page. At present, the service scans every page registered on a daily basis, but the service may become more infrequent as the number of registered users grows.

Web Robot works by storing a unique checksum for every registered page. When it retrieves your registered pages, it runs each one through the checksum algorithm and produces a new checksum,

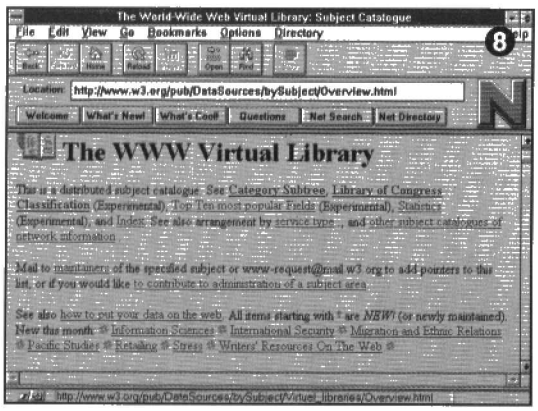

The World Wide Web Virtual Library: Subject Catalogue
File Edit View Go Bookmarks Options Directory
Location: http://www.w3.org/pub/DataSources/bySubject/Overview.html
Welcome What's New! What's Cool! Questions Net Search Net Directory
The WWW Virtual Library

Figure 8. The World Wide Web virtual library is the oldest WWW library, organised and managed by the W3 consortium.

Figure 9. NetSearch allows WWW users to locate companies who maintain a WWW presence.

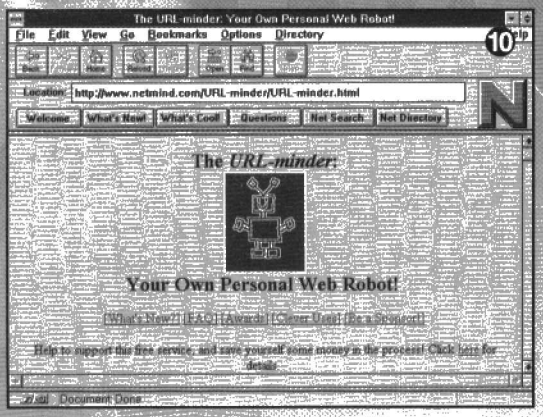

The URL-minder: Your Own Personal Web Robot!
File Edit View Go Bookmarks Options Directory
10
Location: http://www.netmind.com/URL-minder/URL-minder.html
Welcome What's New! What's Cool! Questions Net Search Net Directory
The URL-minder:
Your Own Personal Web Robot!
Document Done

Figure 10. The WWW Robot monitors the contents of selected WWW pages and notifies registered users by e-mail as updates are made to their favourite sites.

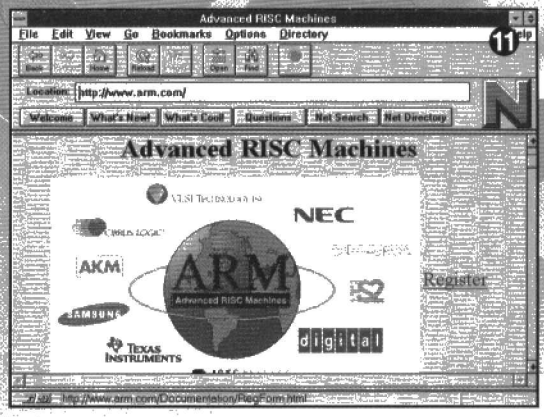


Figure 11. Many electronics companies are using the WWW to provide access to marketing and engineering material. Cambridge based Advanced RISC Machines (ARM) is one such company.

which it compares against the old one stored in the database. If the checksum has changed, the URL-minder sends you (and everyone else who has registered that particular URL) an e-mail message. At present, the service is free and it looks set to stay that way. Net Mind is currently a pilot project. The company is investigating potential sponsorship opportunities as a vehicle for future funding.

Virus Transfer

When the WWW first became the vogue among computer users, concerns were naturally raised concerning the transfer of viruses between machines. While there are no reported instances of viruses being transferred on the back of WWW pages, it is easy to imagine how it might happen. If you download an executable file, or indeed, a non-executable file such as a data or an image file from a WWW site, it is possible that a virus might be embedded within the downloaded code. For this reason, it is always best to protect your machine with resident anti-virus software, such as Dr Solomon's toolkit. This will scan data to check for rogue files as it is downloaded.

Moving Images

The future of the WWW lies in moving images. While some sites currently contain MPEG movies and video clips, these all have to be downloaded and run on the client machine. And as it typically takes 10 minutes to download a 3 minute movie with even the fastest 28.8 modem, this can be a tedious process. Until larger Internet connections via technologies such as ISDN enable video on demand, the growth of video on the Internet will be limited to the odd scattered site, from which clips can be downloaded.

One solution to this problem is that tabled by Sun MicroSystems. The company has developed its own WWW browser, Hot Java. This uses code embedded within WWW pages. These pages are then executed as they are downloaded onto a client machine. This technique works very successfully, however, a high-speed connection to the Internet is still required, and the Hot Java browser requires a high-performance machine. Minimum hardware requirements are an Apple PowerPC, Pentium or surprise, surprise, a Sun Workstation. Sceptics claim that far from being a technological move forward, Hot Java is a marketing ploy from Sun to help them sell more hardware.

The Internet may well be open for business, but the challenge for the business community lies far beyond simply establishing a presence. While WWW pages can be published with similar ease to any facet of the marketing communications portfolio, this does not necessarily mean they have value. The real challenge lies in creating a presence that fulfils a useful service, and that is actually visited by WWW users.

Electronic Surfing

Increasingly, Electronics companies are establishing WWW sites to enable their customers to directly download marketing and technical information. Advanced RISC Machines (ARM) is one such company, as shown in Figure 11.

Advanced RISC Machines, **http://www.arm.com**
Allen-Bradley, **http://www.ab.com**
Altera, **http://www.altera.com**
AMD, **http://www.amd.com**
Apple, **http://www.apple.com**
Brooktree, **http://www.brooktree.com**
Conner Peripherals, **http://www.conner.com**
Cyrix, **http://www.cyrix.com**
Cypress, **http://www.cypress.com**
Dallas Semiconductor, **http://www.dalsemi.com**
Digital Electronics, **http://www.digital.com**
Fujitsu, **http://www.fujitsu.com**
Harris Semiconductor, **http://www.semi.harris.com**
Hewlett Packard, **http://www.hp.com**
Hitachi, **http://www.hitachi.com**
IBM, **http://www.ibm.com**
IEE, **http://www.iee.org.uk**
IEEE, **http://www.ieee.org**
Intergraph Electronics, **http://www.intergraph.com**
Micron Technology, **http://www.micron.com**
Microsoft, **http://www.microsoft.com**
National Instruments, **http://www.natinst.com**
Novell, **http://www.novell.com/**
Philips Semiconductors, **http://www.semiconductors.philips.com/semiconductors** or **http://www.ieee.org**
Richardson Electronics, **http://www.rel.com**
Silicon Graphics, **http://www.sgi.com**
Xicor, **http://www.xicor.com**

Further Browsing

List of available WWW browsers
http://info.cern.ch/hypertext/www/clients.html

IMPORTANT NEWS FOR OVERSEAS READERS!

Obtaining components and kits for the projects featured in ***Electronics*** is now easier than ever in the following countries and regions:

Channel Islands
C.I. Components Ltd.,
Crossways Centre,
Bray Road,
Vale, Guernsey.
Tel: 01481 44177
Fax: 01481 42291

Middle Eastern Region
Saudi Arabia
(Alkhobar Region)
Fadan Establishment,
P.O. Box 848
Alkhobar 31952
Kingdom of Saudi Arabia
Tel: 3 898 2737
Fax: 3 898 2737

United Arab Emirates (U.A.E), Bahrain, Kuwait, Oman, Qatar
Maplin Middle East Company,
P.O. Box 47019,
Hamdan Street,
Abu Dhabi, U.A.E.
Tel: (971) 02 760332
Fax: (971) 02 760317

Lebanon
N and Y Controls,
P.O. Box 175414,
Beirut, Lebanon.
Tel: (01) 443091/397467
UK Office:
Tel: (44) 1702 347614
Fax: (44) 1702 77161

African Continent
South Africa, Namibia, Botswana, Lesotho, Swaziland, Mozambique, Angola, Zimbabwe
Maplin South Africa (Pty) Ltd.,
P.O. Box 1846,
Somerset West, 7129
Republic of South Africa.
Tel: (024) 51 51 24
Fax: (024) 51 51 27

Mediterranean
Malta
Cam Services,Cam Centre,
Off Canon Road, Qormi,
QRM 09, Malta.
Tel: 484650
Fax: 447174

Gibraltar
Mail Order International,
c/o Medsun,
P.O. Box 225,
93-99 Irish Town,
Gibraltar.
Tel: 79797
Fax: 74664

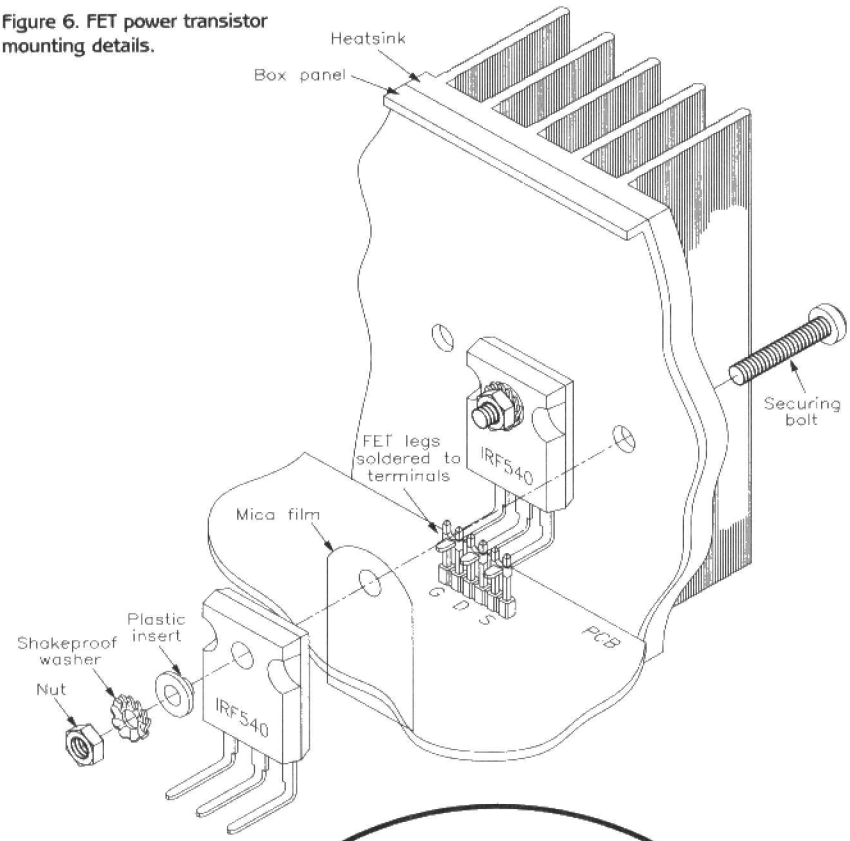
Far Eastern Region
Pakistan
Link Pakistan, Suite Number 2,
2nd Floor,
I-R Plaza, Markaz F-10,
Islamabad, Pakistan.
Tel: 51 291406
Fax: 51 282319

Countries and Regions Not Listed
Export Department,
Maplin Electronics plc.,
P.O. Box 3, Rayleigh,
Essex, SS6 8LR, England.
Tel: +44 1702 554155
xtn 326, 327 or 351
Fax: +44 1702 553935

Export catalogue and pricing details are available from the listed distributors.

MAPLIN
ELECTRONICS AND BEYOND

Figure 6. FET power transistor mounting details.



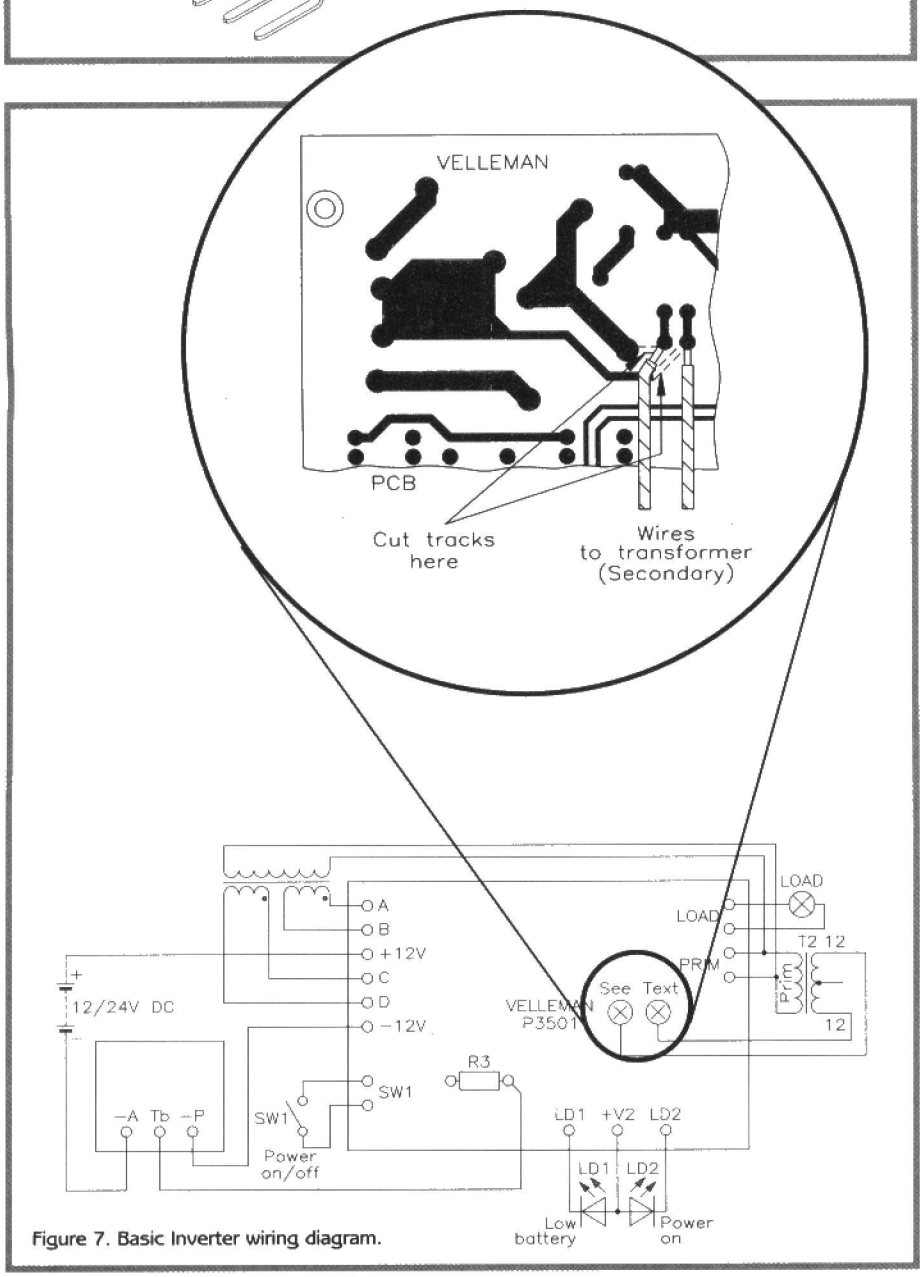


Figure 7. Basic Inverter wiring diagram.

Fit the IC sockets and the 6-way header connectors for T5-8 (these may need to be cut to suit), followed by the 4- and 6-way terminal blocks on the main PCB, and 3-way terminal block on the additional PCB (if required) with the access holes for the cables facing outwards, then install the fuse holder for F1. Plug the appropriate fuse (2A) into the holder, and snap on the cover. Check the completed board(s) carefully for misplaced components, solder bridges, whiskers and dry joints, and remove excess flux using a suitable solvent. Finally, plug the ICs into their sockets, taking antistatic precautions, since they are all CMOS devices.

Casing Construction

The kit does not contain a casing for the unit, but details for installing it into a case are specified in the instruction leaflet supplied. We recommend using the casing specified in the Optional Parts List, which should be drilled in accordance with Figure 3. Note that the holes for the terminal posts should have a keyway filed into them, to prevent the terminal posts from turning when cables are being attached to them. Figure 4 shows the diagram for drilling of the substantial (aluminium) heatsink, which is supplied in the kit. Figure 5 provides a suggested layout of the various parts of the project within a typical casing, although obviously, this does not have to be rigidly adhered to if you are using a different choice of casing. Figure 6 shows the correct method of mounting the MOSFET power transistors to the terminals on the main PCB and to the heatsink. Heat conductive compound should be used between the transistors and the heatsink. The main and additional PCBs are mounted on 10mm insulating spacers.

Figures 7 and 8 provide the wiring diagrams for the basic Inverter and the optional reverse polarity protection wiring, respectively; follow the relevant diagram dependent on the configuration you require. Figures 5 and 9 show the correct method of mounting the toroidal transformer into the metal casing. This method MUST be observed, since if both ends of the central mounting bolt are in contact with the metal housing (the WRONG method!), in effect, an extra 'coil' is created, which, being short-circuited, will cause the transformer to get extremely hot, leading to its early demise. Therefore, ensure that the housing cover does not touch either end of the transformer mounting bolt, or the metal flange. For added protection against this occurring, PVC or similar insulating material can be glued to the inside of the cover, above the transformer. However, this will not be required with the specified casing, since there is a generous gap between the transformer and the cover. The smaller transformer (TF2) is fitted to the casing in the location shown in Figure 5, using M3 screws, shakeproof washers and nuts, as is the fuseholder for F2 (note extra hole for location). The centre tap lead of TF2's secondary coil is not used, and should be cut off and insulated using PVC insulating tape.

Note that the wiring to the terminal posts and between the main board (via the F2 fuseholder) and the additional current-limiting PCB should be done using high current (30A) cable. Use red cable for the

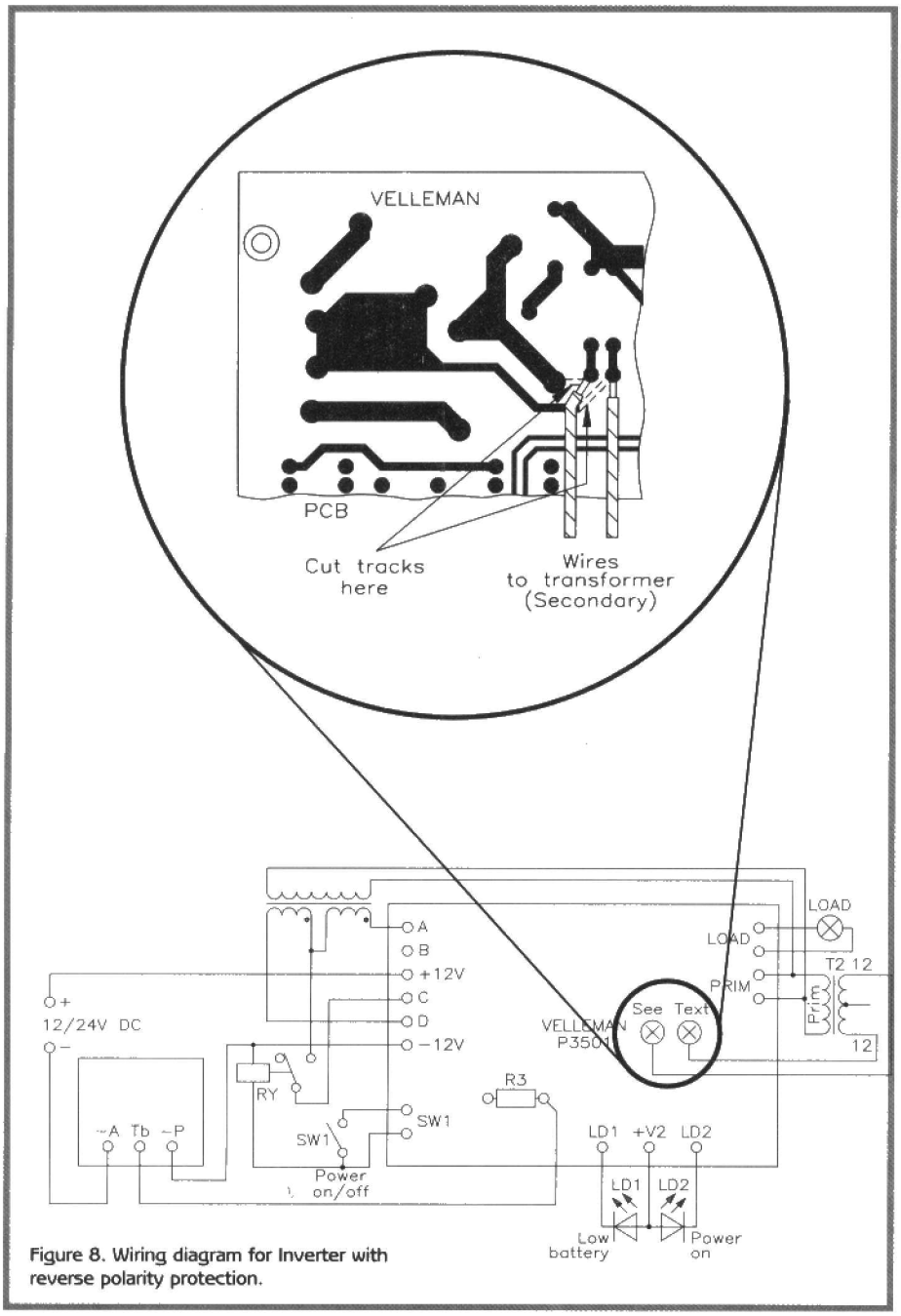


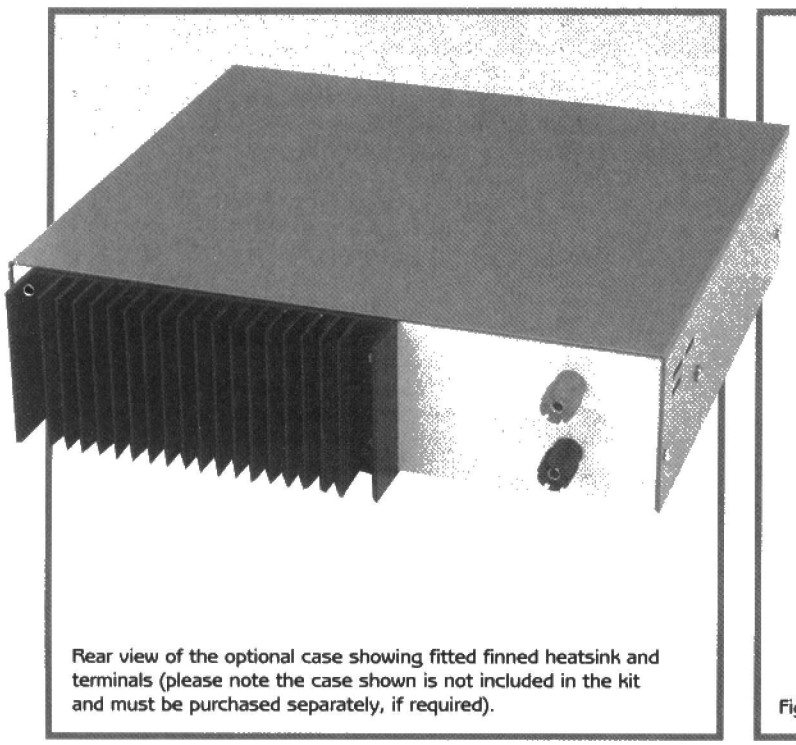
Figure 8. Wiring diagram for Inverter with reverse polarity protection.

positive terminal and black for the negative. The wiring to the Euro outlet socket should be implemented using 6A power wire, brown for the live connection, blue for neutral and green/yellow for the earth (a source of this is 3-core mains cable). The other two earth connections (wired in with green/yellow cable) are made to the black (0V) input terminal, and to the casing lid via a solder tag held in place with an M4 screw, nut and shakeproof washer (see the drilling diagram of Figure 3 for its position). The above earth connections are terminated to three solder tags secured to the casing by an M4 screw and nut, with shakeproof washers in between each tag (4 washers in all), in the position indicated in Figure 5. Ensure that the enamel on the casing (and the lid) is scraped back to bare metal in the region of the earthing points (to at least the same area of the M4 shakeproof washers that are placed next to the casing metal), to ensure a good contact.

Use M3 screws, nuts, and shakeproof washers to secure the Euro socket in position, and fit an insulation cover on the back of the Euro socket for added safety. The on/off switch is a push-fit into the casing, and is held in place by its built-in clips. Hook-up wire is used for wiring in the LEDs and on/off switch. Use insulating sleeving on the LED leads, and LED clips to secure the LEDs into the casing; a spot of instant adhesive or similar can be applied to secure the LEDs into the clips, to prevent them from being pushed into the casing. To keep the wiring tidy, use cable ties to secure them in bundles. Fit the rubber feet supplied with the casing onto the base, to protect surfaces on which the unit is placed. The casing lid is then secured with the four screws supplied with the box. Finally, wipe the casing clean, and apply the safety warning label (see Figure 10), adjacent to the output Euro socket (see photographs).

Testing and Use

The Inverter is very simple to test and use. Simply connect the 12 or 24V DC supply (as appropriate) via the red (+) and black (−)



Rear view of the optional case showing fitted finned heatsink and terminals (please note the case shown is not included in the kit and must be purchased separately, if required).

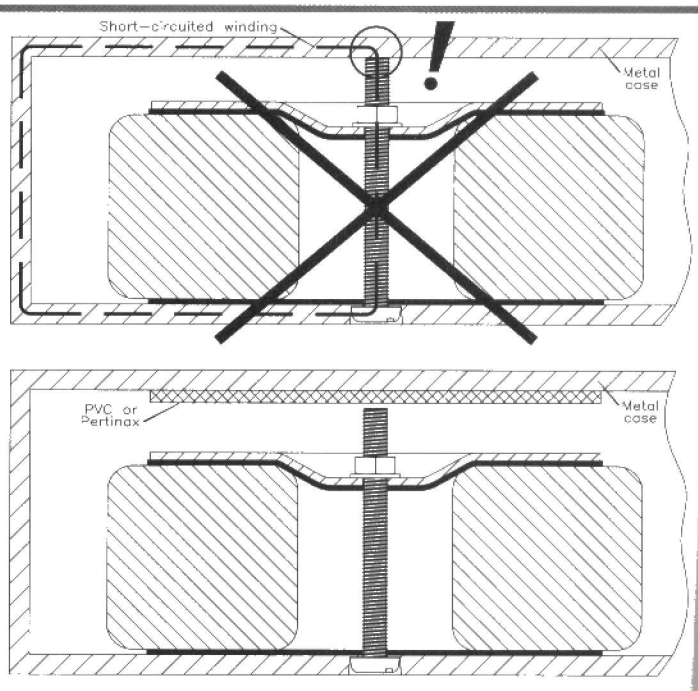


Figure 9. Toroidal transformer mounting diagram.

input terminals, and connect the mains voltage output to the load via a lead terminated in a Euro plug to match the socket – for test purposes, a mains lamp (of any power rating within the power-handling capability of the inverter) will provide a quick visual confirmation that the unit works. Finally, switch on the unit, which should provide an instant source of mains voltage AC power. The red LED (LD2) lights to indicate that the unit is switched on, and the green LED (LD1) indicates a low battery level (the red LED is extinguished if the green LED lights). Note that initial adjustment of the output voltage level may be required, which is easily accomplished by altering the setting of potentiometer RV1 – do this with the power off. The voltage should be adjusted until around 210V rms is indicated on a multimeter when connected in parallel with a typical load, such as a 100W lamp, though bear in mind that a multimeter reading will read around 10% too high, since the unit does not provide a pure sinusoidal output waveform.

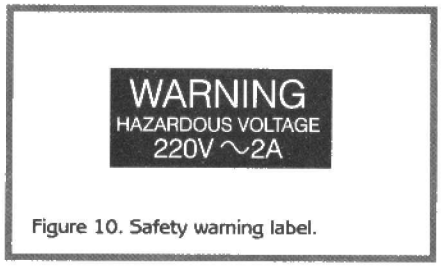


Figure 10. Safety warning label.

The unit will warn if the battery is running too low for effective inversion to take place, by means of the low battery warning LED, and the unit will automatically cut out if the input voltage drops below preset levels, to avoid totally draining a low battery. Always operate the inverter strictly in accordance with the safety guidelines printed at the head of this article.

12/24V TO 220V INVERTER PARTS LIST

RESISTORS: All 0·25W Metal Film (Unless Stated)

R1	12V Inverter: 47Ω	1
	24V Inverter: 560Ω 0·5W Metal Film	1
R2	1k	1
R3	10k	1
R4-7	22k	4
R8,9	330Ω	2
R10	10MΩ	1
R11,12	100Ω	2
R13	1k5	1
R14	4k7	1
R15	820Ω	1
R16	18k	1
R17	150Ω 1W	1
R18	560Ω 0·6W 5% Metal Film	1
R19	100k 1W	1
R20	1k8	1
R21	680Ω	1
R22-24	0Ω1 5W	3
RV1	5k Horizontal Preset Potentiometer	1

CAPACITORS

C1,2	15pF Ceramic Disc	2
C3	100nF 63V Monolithic Ceramic	1
C4,5	10µF 63V Radial Electrolytic	2
C6	220nF 600V Metallised Polypropylene	1
C7	100µF 35V Radial Electrolytic	1
C8	10nF Ceramic Disc	1

SEMICONDUCTORS

D1-5	1N4007	5
ZD1	12V Inverter: 15V 500mW Zener	1
	24V Inverter: 7V5 500mW Zener	1
ZD2	2V4 500mW Zener	1
ZD3	10V 1·3W Zener	1
ZD4,5	150V 3·25W Zener	2
LD1	3mm Red LED	1
LD2	3mm Green LED	1
T1-3,5	BC547B	4
T4	BC557B	1
T5-8	100V/28A N-channel Power MOSFET TO3P Case	4
IC1	4060BE	1
IC2	4001BE	1
IC3	4013BE	1

MISCELLANEOUS

SW1	SPST Rocker Switch 3A 250V	1
F1	2A Time Delay Fuse	1
F2	15A Time Delay Fuse	1
L1	50µH Toroidal Choke	1
X1	3·2768MHz Crystal	1
	14-pin DIL Socket	2
	16-pin DIL Socket	1
	M3 × 15mm Bolt	12
	M3 Nut	12
	M3 × 10mm Plastic Spacers	4
	M3 Lock Washer	4
	3mm LED Clips	2
	PCB Mounting Fuseholder	2
	Fuseholder Cover	2
	7mm 6-pin Header	4
	TO3P Mica Insulators	4
	TO220 Insulation Ring	4
	Heatsink	1
	3-way PCB Mounting Terminal Block	1
	4-way PCB Mounting Terminal Block	1
	6-way PCB Mounting Terminal Block	1
	Current Limiting Section PCB	1
	PCB Pins	10
	PCB	1
	Instruction Manual	1
	Instruction Leaflet	1
	Constructors' Guide	1

SUPPLEMENTARY MISCELLANEOUS

TF2	12-0-12V 100mA Sub-miniature Transformer	1	(WB02C)
R19	1kΩ 0·6W	1	(M1K)
R16	10kΩ 0·6W	1	(M10K)
	Red 30A Terminal Post	1	(CX83E)
	Black 30A Terminal Post	1	(CX84F)
	15A Fast Acting 31mm Glass Fuse	1	(DA33L)
	31mm Panel-mounting Fuseholder	1	(DA65V)
	M4×10mm Steel Screw	2	(JY14Q)
	M4 Steel Nut	2	(JD60Q)
	M4 Solder Tag	4	(LR63T)
	M4 Shakeproof Washer	6	(BF43W)
	M3×6mm Steel Screw	3	(JY21X)
	M3×6mm Countersunk Head Steel Bolt	2	(BF36P)
	M3 Shakeproof Washer	5	(BF44X)
	M3 Steel Nut	5	(JD61R)
	3-core 3A Mains Cable	1m	(XR01B)

OPTIONAL (Not in Kit)

TF1	12V Inverter Transformer 1609	1	(VF69A)
TF1	24V Inverter Transformer 30022	1	(VF70M)
	Aluminium Case Type 52-43	1	(KR14Q)
SW2	Large Push-to-make Switch	1	(FH91Y)
	M3×10mm Insulated Spacers	1 Pkt	(FS36P)
	Euro Outlet Socket P675	1	(FT63T)
	Insulated Euro Socket Cover	1	(JK68Y)
	16swg Tinned Copper Wire	1 Reel	(BL11M)
	Cable Tie	4	(BF91Y)
	Heat Resistant Sleeving Red	1m	(BL70M)
	Black High Current Wire	1m	(XR57M)
	Red High Current Wire	1m	(XR59P)
	Brown 6A Power Wire	1m	(XR34M)
	Blue 6A Power Wire	1m	(XR33L)
	Black Hook-up Wire	1 Pkt	(BL00A)

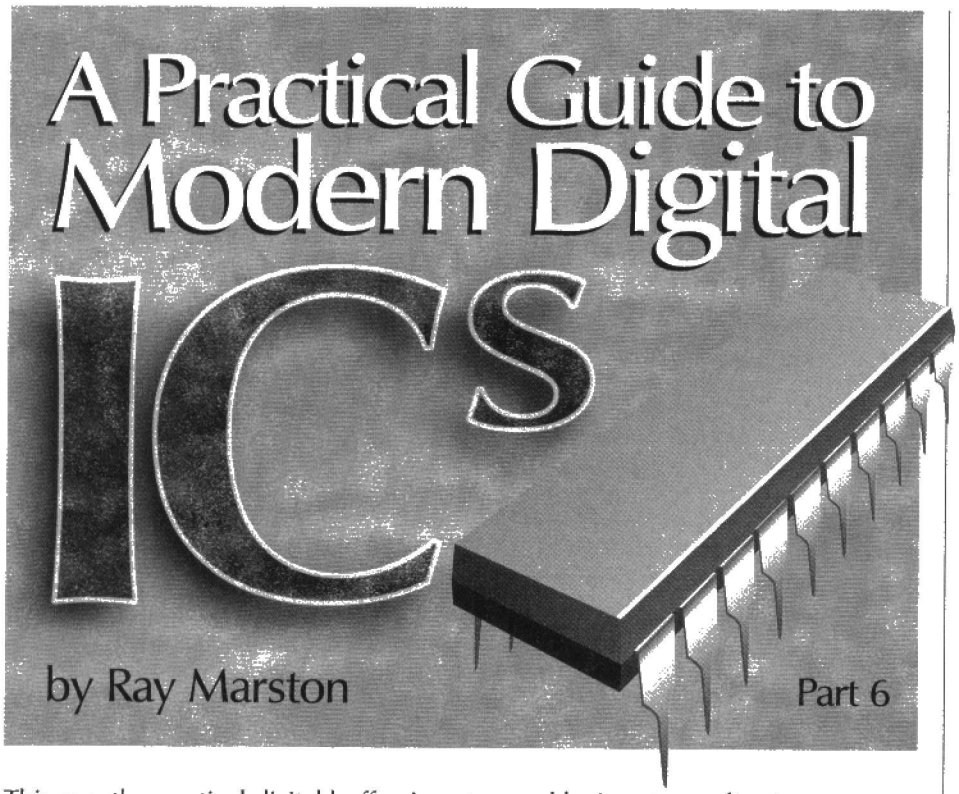
The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available in kit form only.

Order As 95013 (220V Inverter) Price £49.99B1

Please Note: Some parts, which are specific to this project (e.g., PCB), are not available separately.

A Practical Guide to Modern Digital ICs



by Ray Marston

Part 6

This month, practical digital buffer, inverter, and logic-gate applications are discussed. Earlier parts of this series explained TTL and CMOS principles and basic usage rules, and looked at the '74' and '4000' series of ICs and at various submembers of these families. The 'digital ICs' theme continues by showing practical ways of using TTL and CMOS buffers, inverters, and logic-gate ICs.

Logic Gate Symbology

The eight best known types of logic 'gate' are the buffer and the NOT, OR, NOR, AND, NAND, EX-OR and EX-NOR types. Many different symbols can be used to represent each of these eight basic logic gate elements. Figure 1 shows four different families of symbols that are widely used in various parts of the world today; of these, the American MIL/ANSI symbols are by far the most popular, are instantly recognisable, are used by most practical digital engineers throughout the world, and are used exclusively throughout the rest of this series. Two useful variations of these American symbols are also widely used and are shown added to a standard inverter symbol in Figure 2; the left-hand symbol is internationally recognised and indicates that the logic element has a Schmitt-trigger input action; the right-hand symbol (which is widely used but is not universally recognised) indicates that the logic element has an open-drain (o.d.) or open-collector (o.c.) output stage.

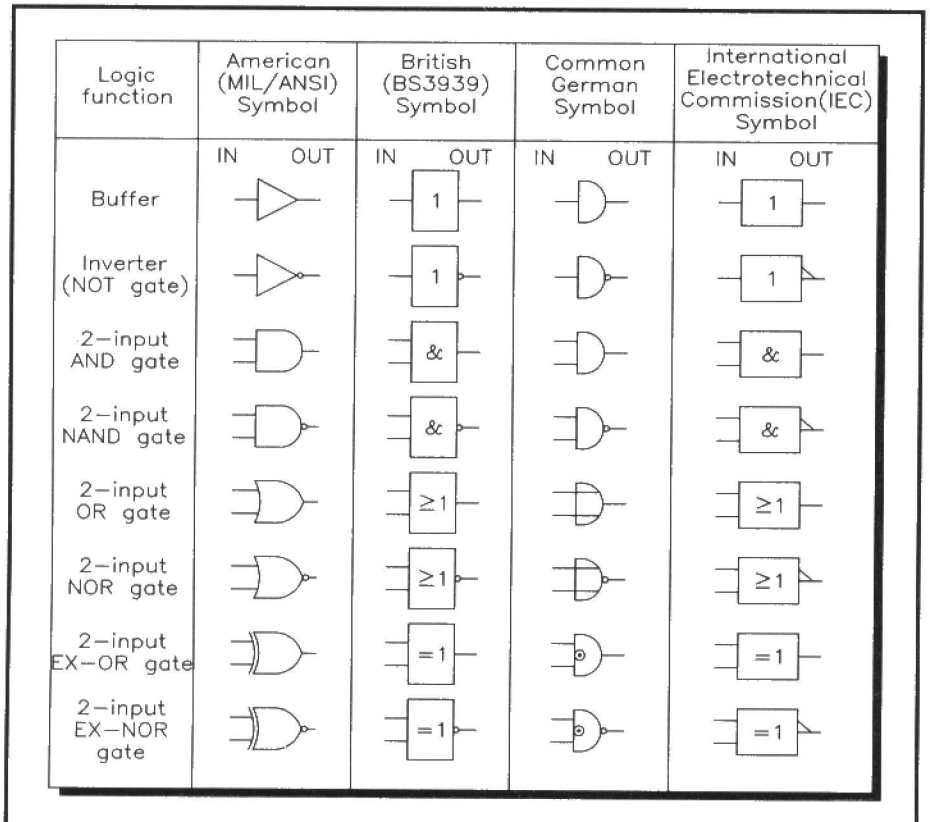


Figure 1. A selection of widely used logic symbols.

Logic Gate Functions

The functional action of any logic gate can be presented or represented in either a descriptive, tabular, or symbolic way. The following list presents the functions of all eight basic types of gate in purely descriptive terms.

Buffers

A buffer is simply a non-inverting amplifier that has an output drive capacity that is far greater than its input drive requirement, i.e., it has a high fan-out and gives a logic-1 output for a logic-1 input, etc.

Inverters

An inverter is an amplifier with a high fan-out, and gives a logic-1 output for a logic-0 input, and vice-versa; an inverter may also be known as a NOT gate.

AND Gates

An AND gate has an output that is normally at logic-0 and only goes to logic-1 when ALL inputs are at logic-1, i.e., when inputs A *AND* B *AND* C, etc., are high.

NAND Gates

A NAND gate is an AND gate with a negated (inverted) output; it has an output that is normally at logic-1 and only goes to logic-0 when ALL inputs are at logic-1.

OR Gates

An OR gate has an output that goes to logic-1 if ANY input is at logic-1, i.e., if inputs A *OR* B *OR* C, etc., are high. Note that the output goes to logic-0 only if ALL inputs are at logic-0.

NOR Gates

A NOR gate is an OR gate with a negated output; it has an output that goes to logic-0 if any input is at logic-1, and goes to logic-1 only when ALL inputs are at logic-0.

EX-OR Gates

Exclusive-OR (EX-OR) gates have two inputs, and their output goes to logic-1 only if a

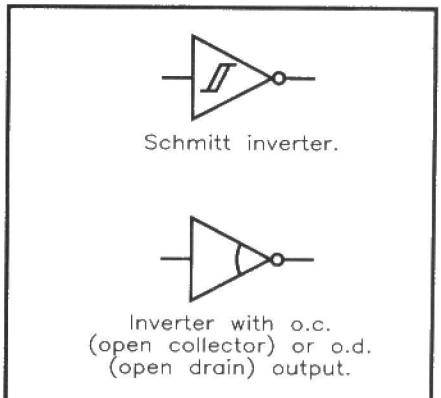


Figure 2. Useful variations of the MIL/ANSI inverter symbol.

SINGLE input (A *OR* B) is at logic-1; the output goes to logic-0 if BOTH inputs are in the same logic state.

EX-NOR Gates

An Exclusive-NOR (EX-NOR) gate is an EX-OR gate with a negated output, which goes to logic-1 if BOTH inputs are in the same logic state, and goes to logic-0 only if a single input is at logic-1.

Figure 3 shows how the functions of these eight gates can also be presented in tabular form, via Truth Tables (which show the logic state of the output at all possible combinations of input logic states), or symbolically, in Boolean algebraic terms. Note when representing logic gate functions that, by convention, all inputs are notated alphabetically as 'A', 'B', 'C', etc., and the output terminal is notated as 'Y' (but in counters and flip-flops, etc., the main output is usually notated as 'Q'); the actual logic states may be represented by '0' and '1', as shown, or by 'L' (= Low logic level) and 'H' (= High logic level). Also note in the Boolean expressions that a negated output is indicated by a negation bar drawn above the basic output symbol; the negated state is called a *'not'* state; thus, a negated 'Y' output is called a *'not-Y'* output.

Positive versus Negative Logic

All modern logic circuitry assumes the use the 'positive logic' convention, in which a logic-1 state is High and a logic-0 state is Low. In the early days of electronic digital circuitry, an alternative 'negative logic' convention (in which a logic-1 state is Low and a logic-0 state is High) was also in common use, and it is sometimes still useful to be able to think in negative-logic terms, particularly when designing gates in which a Low-state output is of special interest. With this point in mind, Figure 4 presents a basic set of 2-input Positive and Negative logic equivalents. Thus, it can be seen that a Negative logic AND gate action (in which the output is Low only when both inputs are Low) is directly available from a Positive logic OR gate, and so on.

Practical Buffer IC Circuits

Digital buffer ICs have two main purposes, and these are to either act as simple non-inverting current-boosting interfaces between one part of a circuit and another, or to act as 3-state switching units that can be used to connect a circuit's outputs to a load only when required. If you ever need only a few simple buffers, one cheap way to get them is to make them from spare AND or OR elements, as shown in Figure 5, or from pairs of normal or Schmitt inverters, as shown in Figure 6.

Figure 7 lists basic details of nine popular non-inverting buffer ICs. The 74LS125 'Quad'

Logic function	Logic symbol	Truth table	Boolean expression
Buffer	A — Y	A | Y 0 | 0 1 | 1	Y=A
Inverter (NOT gate)	A — Y	A | Y 0 | 1 1 | 0	$Y=\overline{A}$
2-input AND gate	A, B — Y	A B | Y 0 0 | 0 0 1 | 0 1 0 | 0 1 1 | 1	Y=A•B
2-input NAND gate	A, B — Y	A B | Y 0 0 | 1 0 1 | 1 1 0 | 1 1 1 | 0	$Y=\overline{A \bullet B}$
2-input OR gate	A, B — Y	A B | Y 0 0 | 0 0 1 | 1 1 0 | 1 1 1 | 1	Y=A+B
2-input NOR gate	A, B — Y	A B | Y 0 0 | 1 0 1 | 0 1 0 | 0 1 1 | 0	$Y=\overline{A+B}$
2-input EX-OR gate	A, B — Y	A B | Y 0 0 | 0 0 1 | 1 1 0 | 1 1 1 | 0	$Y=A \oplus B$
2-input EX-NOR gate	A, B — Y	A B | Y 0 0 | 1 0 1 | 0 1 0 | 0 1 1 | 1	$Y=\overline{A \oplus B}$

Figure 3. Symbols, Truth Tables, and Boolean expressions for eight basic types of logic gate.

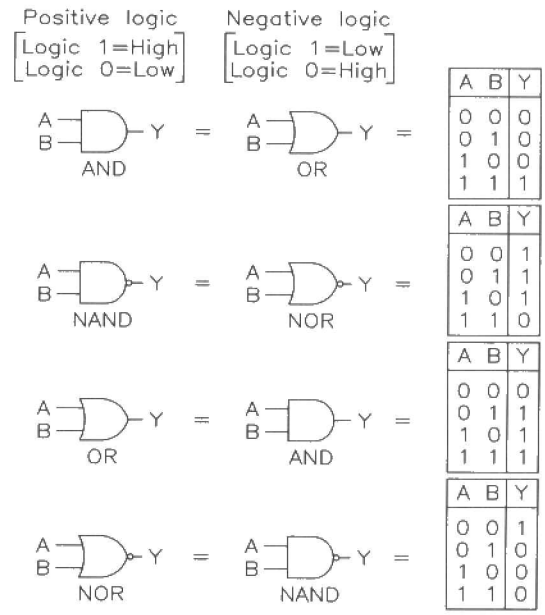


Figure 4. Basic sets of 2-input Positive and Negative logic equivalents.

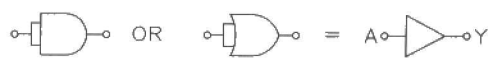


Figure 5. Any AND or OR gate can be used as a non-inverting buffer element.

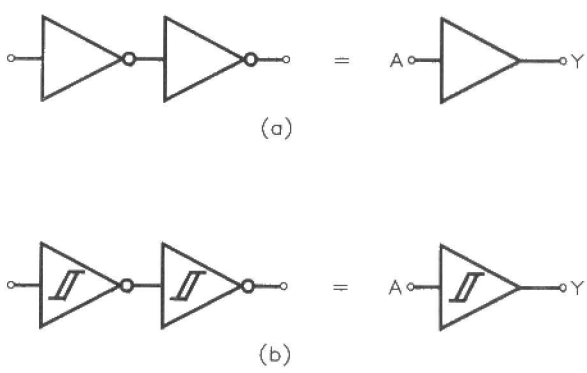


Figure 6. Any two elements from an inverter IC can be used to make a non-inverting buffer element.

IC houses four independently-controlled 3-state buffers. The 4050B and 74HC4050 are simple Hex buffers, and the 7407 is a Standard TTL Hex buffer with open-collector outputs that have a 30V DC rating. The 4503B is a Hex 3-state buffer with two separate mode control inputs, one controlling two buffers and the other controlling four buffers. The 74LS365 is a Hex 3-state buffer, with the modes of all six buffers controlled via a single 2-input AND gate. The 74HC241, 74HC244, and 74LS244 are Octal 3-state Schmitt buffers in which the buffers are split into two groups of four, with the mode of each group controlled via a separate input.

Device	Type	Description
74LS125	LS TTL	Quad 3-state buffer
4050B	CMOS	Hex buffer
4503B	CMOS	Hex (Dual + Quad) 3-state buffer
7407	TTL	Hex buffer with 30V o.c. outputs
74LS365	LS TTL	Hex 3-state buffer
74HC4050	CMOS	Hex buffer
74HC241	CMOS	Octal (Dual Quad) 3-state Schmitt buffer
74HC244	CMOS	Octal (Dual Quad) 3-state Schmitt buffer
74LS244	LS TTL	Octal (Dual Quad) 3-state Schmitt buffer

Figure 7. Nine popular non-inverting buffer ICs.

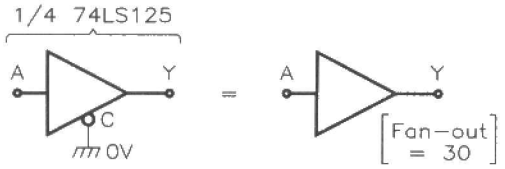


Figure 8. Methods of using a 74LS125 element as a normal buffer.

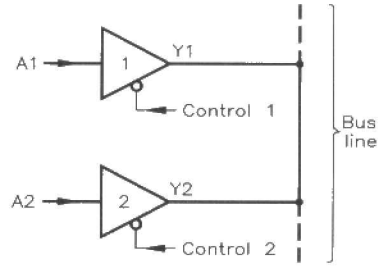


Figure 9. Methods of using a 74LS125 element as a 3-state line-driving buffer.

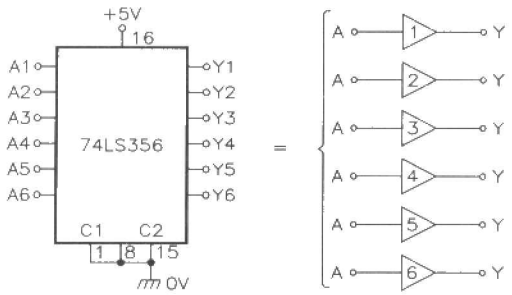


Figure 10. Methods of connecting the 74LS356 for use as six normal buffers.

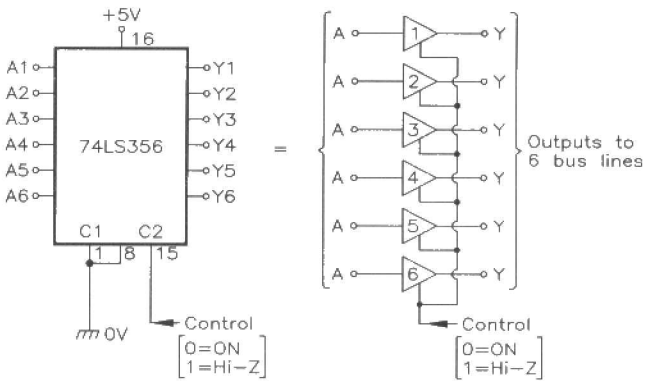


Figure 11. Methods of connecting the 74LS356 for use as a 3-state Hex buffer controlled via a single input.

Figure 12. Any NAND or NOR gate can be used as an inverting buffer element.

Device	Type	Description
7404	TTL	Hex inverter
74HC04	CMOS	Hex inverter
74HCU04	CMOS	Unbuffered Hex inverter
74LS05	LS TTL	Hex inverter with o.c. outputs
74LS14	LS TTL	Hex Schmitt inverter
74HC14	CMOS	Hex Schmitt inverter
4049UB	CMOS	Unbuffered Hex inverter
4069UB	CMOS	Unbuffered Hex inverter
4502B	CMOS	Hex 3-state inverter
40106B	CMOS	Hex Schmitt inverter
74LS240	LS TTL	Octal 3-state Schmitt inverter

Figure 13. Eleven popular inverter ICs.

Device	Type	Description
74LS08	LS TTL	Quad 2-input AND gate
74HC08	CMOS	Quad 2-input AND gate
4081B	CMOS	Quad 2-input AND gate
74LS11	LS TTL	Triple 3-input AND gate
4073B	CMOS	Triple 3-input AND gate
74LS21	LS TTL	Dual 4-input AND gate
4082B	CMOS	Dual 4-input AND gate

Figure 14. Seven popular AND gate ICs.

Note that any 3-state buffer can be used as a 'normal' buffer by simply tying its control inputs into the appropriate states. The 74LS125 Quad 3-state buffer elements, for example, can be used as normal buffers by tying their control pins low, as shown in Figure 8, or as 3-state line-driving buffers by using the connections shown in Figure 9. The 74LS356 Hex IC, on the other hand, can be used as six normal buffers by tying both of its control inputs (pins 1 and 15) low, as shown in Figure 10, or as 3-state elements by using the connections shown in Figure 11.

Practical Inverter IC Circuits

The inverter is the most basic of all digital logic elements, and is sometimes called an inverting

When using these ICs, note that all unused buffers must be disabled by tying their inputs to one of the IC's supply lines. In CMOS devices, the unused inputs can be tied directly to either supply line, but in TTL devices it is best (for lowest quiescent current consumption) to tie all unused inputs high via a common 10kΩ resistor; if the unused buffer is a 3-state type, it should (if it has independent control) be set into its 'normal' mode via its control input.

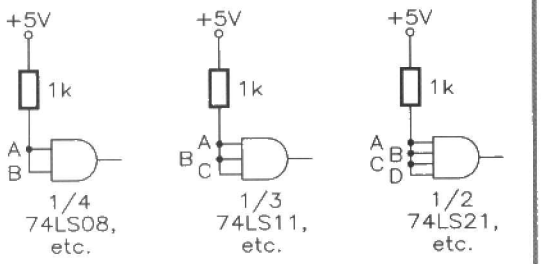


Figure 15. Methods of disabling unwanted TTL AND gates.

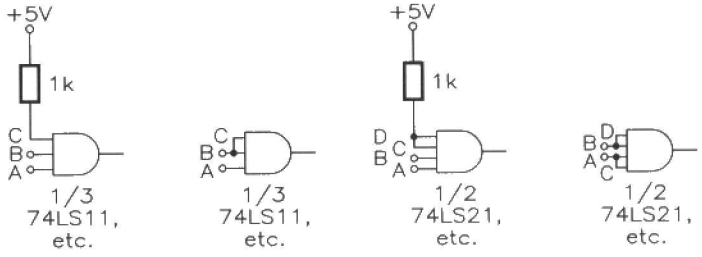


Figure 16. Methods of disabling unwanted TTL inputs, to make a 2-input AND gate.

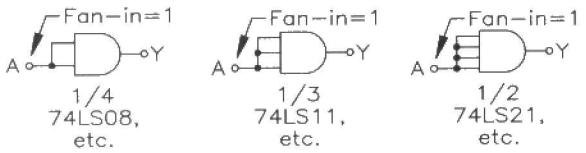


Figure 17. Methods of using TTL and gates as simple buffers.

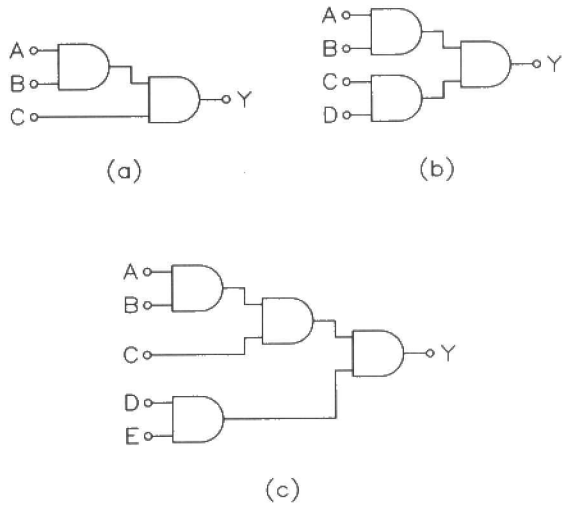


Figure 18. Ways of using 2-input AND gates to make (a) 3-input, (b) 4-input, or (c) 5-input AND gates.

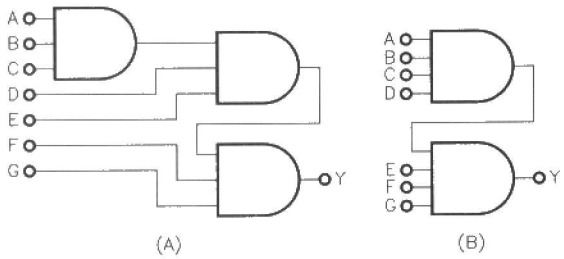


Figure 19. Ways of using (a) 3-input or (b) 4-input AND gates to make a 7-input AND gate.

Device	Type	Description
4011B	CMOS	Quad 2-input NAND gate
4093B	CMOS	Quad 2-input Schmitt NAND gate
74LS00	LS TTL	Quad 2-input NAND gate
74HC00	CMOS	Quad 2-input NAND gate
74LS132	LS TTL	Quad 2-input Schmitt NAND gate
74HC132	CMOS	Quad 2-input Schmitt NAND gate
74LS10	LS TTL	Triple 3-input NAND gate
4023B	CMOS	Triple 3-input NAND gate
74LS20	LS TTL	Dual 4-input NAND gate
4012B	CMOS	Dual 4-input NAND gate
74LS30	LS TTL	8-input NAND gate
4068B	CMOS	8-input NAND gate
74HC133	CMOS	13-input NAND gate

Figure 20. Thirteen popular NAND gate ICs.

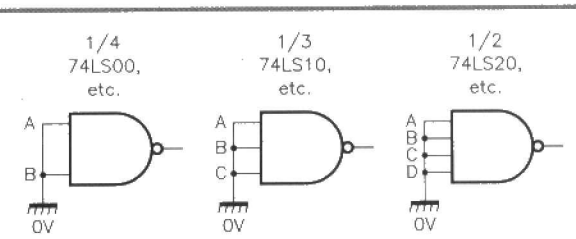


Figure 21. Methods of disabling unwanted TTL NAND gates.

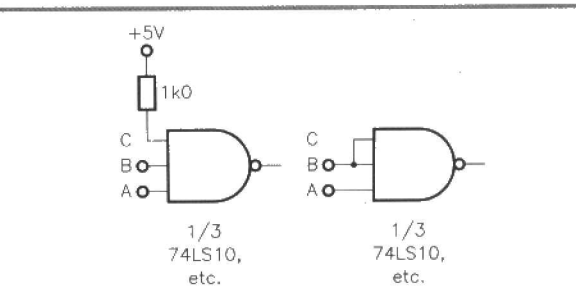


Figure 22. Basic method of disabling unwanted TTL NAND gate inputs.

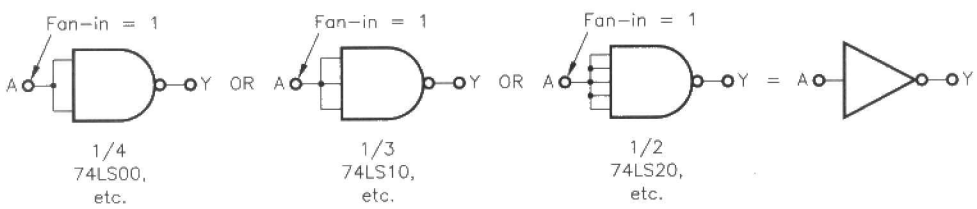
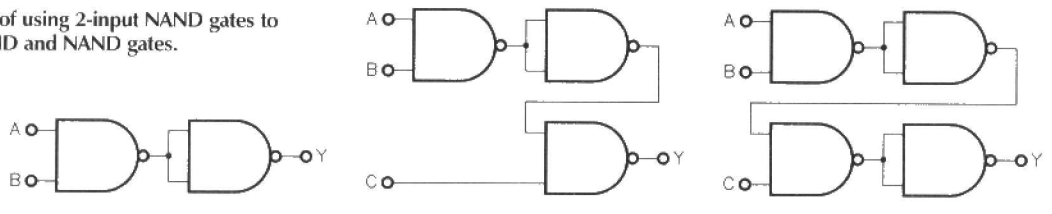


Figure 23. Methods of using TTL NAND gates as simple inverters.

Figure 24. Ways of using 2-input NAND gates to make various AND and NAND gates.



buffer. If you ever need only a few simple inverters, one cheap way to get them is to make them from spare NAND or NOR elements, connected as shown in Figure 12.

Figure 13 lists basic details of eleven popular inverter ICs. The 7404 is a simple Hex inverter; it is also available in fast CMOS form as the 74HC04, and in fast unbuffered CMOS form (for use in 'linear' applications) as the 74HCU04. The 74LS05 is a Hex inverter with open collector outputs. The 74LS14 and 74HC14 are Hex Schmitt inverters, and the 4049UB and 4069UB are unbuffered Hex inverters. The 4502B is a Hex 3-state inverter, and the 40106B is a Hex Schmitt inverter. The 74LS240 is an Octal 3-state Schmitt inverter in which the eight inverters are divided into two groups of four, with the mode of each group controlled via a separate input.

When using these ICs, note that all unused inverters must be disabled by tying their inputs to one of the IC's supply lines. In CMOS devices, the unused inputs can be tied directly

Device	Type	Description
74LS32	LS TTL	Quad 2–input OR gate
74HC32	CMOS	Quad 2–input OR gate
4071B	CMOS	Quad 2–input OR gate
4075B	CMOS	Triple 3–input OR gate
74HC4075	CMOS	Triple 3–input OR gate
4072B	CMOS	Dual 4–input OR gate

Figure 25. Six popular OR gate ICs.

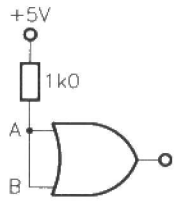


Figure 26. Method of disabling a TTL OR gate.

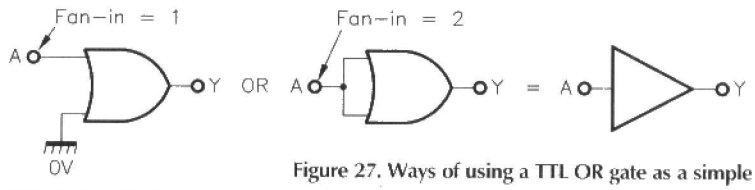
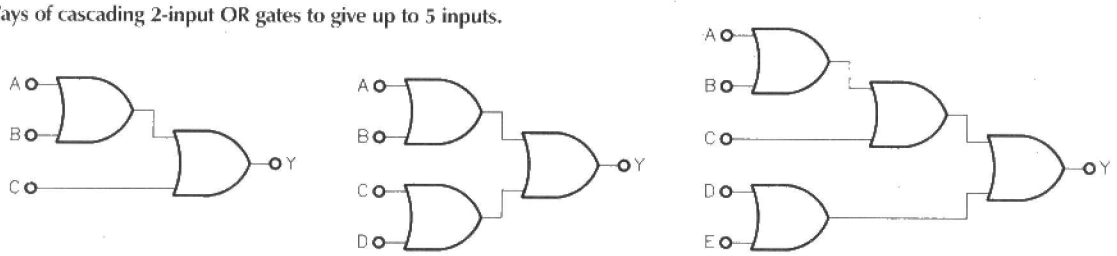


Figure 27. Ways of using a TTL OR gate as a simple buffer.

Figure 28. Ways of cascading 2-input OR gates to give up to 5 inputs.



to either supply line, but in TTL devices it is best (for lowest quiescent current consumption) to tie all unused inputs directly to the 0V rail; if the unused inverter is 3-state type, it should (if it has independent control) be set into its 'normal' mode via its control input.

Practical AND Gate IC Circuits

The output of an AND gate goes high (to logic-1) when all of its inputs (A *AND* B *AND* C, etc.) are high. Figure 14 lists basic details of seven popular AND gate ICs; the 74LS08, 74HC08, and 4081B are Quad 2-input types, the 74LS11 and 4073B are Triple 3-input types, and the 74LS21 and 4082B are Dual 4-input types.

When using AND gate ICs, each unwanted gate must be disabled by shorting all of its inputs together and tying them to one of the IC's supply lines. In CMOS ICs, the shorted inputs can be wired directly to either supply line, but in TTL ICs the inputs must (to give minimum quiescent current consumption with good stability) be tied to the positive supply rail via a single 1kΩ resistor, as shown in Figure 15; a single resistor can be used as a tie-point for large numbers of unwanted inputs.

Sometimes, when using 3-input or 4-input

Device	Type	Description
74LS02	LS TTL	Quad 2–input NOR gate
74HC02	CMOS	Quad 2–input NOR gate
4001B	CMOS	Quad 2–input NOR gate
4001UB	CMOS	Unbuffered Quad 2–input NOR gate
4002B	CMOS	Dual 4–input NOR gate
74LS260	LS TTL	Dual 5–input NOR gate
4025B	CMOS	Triple 3–input NOR gate
74LS27	LS TTL	Triple 3–input NOR gate
74HC27	CMOS	Triple 3–input NOR gate
4078B	CMOS	8–input NOR gate

Figure 29. Ten popular NOR gate ICs.

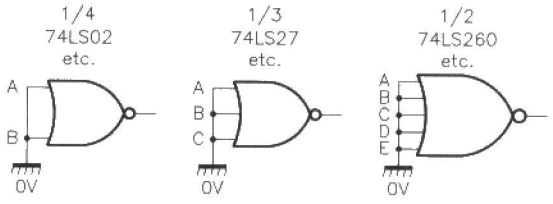


Figure 30. Ways of disabling TTL NOR gates.

Continued on page 55.

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I don't know Doris I'm getting bad vibes about this one

More on Tin-plate

One of the comforting aspects of writing this column is the assistance PC receives from the ever-helpful *Electronics* readers. In an earlier issue (No. 96 – Ed), PC bemoaned the fact that tin cans, which he had regularly employed as a source of tin-plate for use as screens in RF circuits, nowadays come with a band of corrugations around the middle. PC learns from one reader that this is because the gauge of metal used has been reduced (in the interests of economy) to the point where the corrugations are necessary to avoid tins being too prone to denting. Furthermore, to save the cost of tin, which is much more expensive than formerly, the tin-plating has been replaced by a layer of lacquer. Steel was always reckoned to be difficult to solder to, though this was often because of surface oxidation, whereas the tin-plating made soldering to it simple. Fortunately, the lacquer, which comes in clear, gold or other colours, seems to act as a good self-fluxing protective layer. J.C.R. of Stockport wrote to say that small tins of you know whose baked beans (the 205g size) are corrugation free, presumably the small size tins being less likely to get dented. A visit to a supermarket confirmed that the label was the usual wraparound paper variety – easily removed. A letter from F.J.H. of Hayling Island pointed out that various biscuit and sweet manufacturers market their goodies (especially in the festive season, but all year in other cases) in tins, round or square, up to 8 × 8in. – clearly this correspondent is not of such tender years as to have been brought up on the metric system rather than Old English Imperial measurements! Unfortunately, the labelling is printed direct on the tin, unlike the easily removed baked beans tin wrapper. Another reader kindly supplied PC with enough sheet 'tin-plate' to keep him going for many moons. Thank you to all of my readers who have written in with useful information over the years.

News Snippets from Here and There

Japan's Power Reactor and Nuclear Fuel Development Corporation announced on 29th August that its prototype fast breeder reactor, which is the cornerstone of its programme for energy production using plutonium, had generated electricity for the first time. Costing over 600 million dollars, the reactor, which is situated on the coast by the Sea of Japan, operated for an hour, producing about 5% of its rated 280MW capacity. One can understand the power problem in a land virtually devoid of coal, oil or other traditional energy resources, but one cannot help wondering if, despite fulfilling the world's energy needs (for example, most of France's electricity is nuclear generated), mankind is not storing up an insoluble storage/disposal problem for our distant descendants.

There has long been speculation in the technical press as to whether the electric and/or magnetic fields associated with the mains are harmful to humans. In addition to work in the UK and other countries, the US Congress mandated an advisory panel, the National Council on Radiation Protection and Measurements, to study the problem. On 29th August, they reported after a ten year study, that some health effects linked to electromagnetic fields appear real, and warrant steps to reduce exposure to them. They recommend that houses should not be built directly under high voltage overhead transmission lines, and that school playgrounds should not be in areas where the ambient magnetic field exceeds 0·2μT. Many readers will know of cases in their own localities where these recommendations would certainly cause some changes if implemented.

Meanwhile, back in Japan, researchers at the University of Tokyo report that they have developed a substance which can act either as an insulator or as a conductor, depending on the strength of the ambient magnetic field. The material is a compound containing calcium, manganese and oxygen atoms bonded to praseodymium. In the absence of a magnetic field, the material has a resistance of 10GΩ, whereas in the presence of a magnetic field of 3T its resistance drops to 1mΩ, putting it on a par with copper. It would appear to offer the ideal solution to the switch problem, with no moving parts, negligible conduction losses when on and perfect isolation when off, but there is one small snag; it has to be cooled to 4K, liquid helium temperature, to make it work.

Tailpiece

This month, I reproduce another snippet from the *B.B.C. Yearbook* for 1930, a quote on page 43 from the greatest violinist of his day (see below left). Wireless in those days was as new and exciting as television was just after the Second World War, and new aspects of broadcasting were still being explored. (In fact, on page 78, there is a photograph of some technicians manning an outside broadcast van, broadcasting the Silence on 11th November 1928.) Broadcasting still, it can be argued, supports the arts in general; for example, sales of the works of Jane Austen have, I imagine, never been more buoyant. Meanwhile, look out for more gems from the yearbook in future issues, including another of Heath Robinson's delicious fantasies.

Yours sincerely,

Point Contact

> Kreisler in an interview on wireless reported in the press of March 14th, 1929, said—
>
> "We artists really thought at first that few would take the trouble to go to a concert hall when they could enjoy the same concert in all comfort at home. But, paradoxical as it may seem, the opposite thing has happened."

The opinions expressed by the author are not necessarily those of the publisher or the editor.

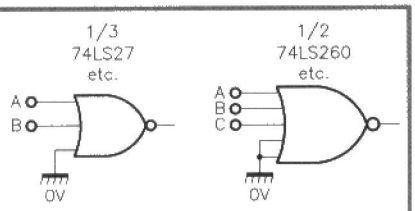


Figure 31. Basic ways of disabling unwanted TTL NOR gate inputs.

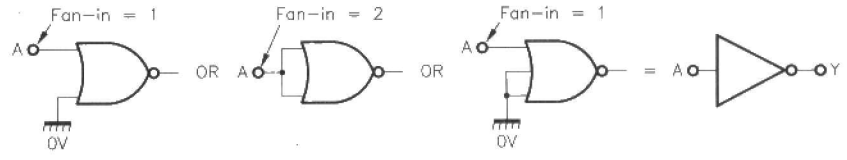


Figure 32. Ways of using a TTL NOR gate as a simple inverter.

AND gate ICs, you may not want to use all of a gate's input terminals. In this case, the unwanted inputs can be disabled by either tying them high (directly in CMOS gates, or via a 1kΩ resistor in TTL types) or by simply shorting them directly to a used input; Figure 16 shows examples of 3-input and 4-input TTL AND gates wired for use as 2-input types. Note that the fan-in of a TTL AND gate is an almost constant '1', irrespective of the number of inputs used. Thus, CMOS or TTL AND gates can be converted into non-inverting buffers by simply shorting all of their inputs together; Figure 17 shows examples of TTL AND gates used as simple buffers.

A useful feature of AND gate ICs is that their gates can be directly cascaded, with the output of one gate feeding directly into one input of another gate, to make compound AND gates with any desired number of inputs. Figure 18, for example, shows how 2-input AND gates can be cascaded to make 3-input, 4-input, or 5-input AND gates, and Figure 19 shows three 3-input or two 4-input gates cascaded to make a single 7-input AND gate.

Practical NAND Gate IC Circuits

The output of a NAND gate goes low when all of its inputs (A *AND* B, etc.) are high. Figure 20 lists basic details of thirteen popular NAND gate ICs; the 74LS00, 74HC00, and 4011B are standard Quad 2-input types, and the 4093B, 74LS132 and 74HC132 are Schmitt Quad 2-input types. The 74LS10 and 4023B are Triple 3-input standard types, the 74LS20 and 4012B are Dual 4-input standard types, the 74LS30 and 4068B are 8-input standard types, and the 74HC133 is a 13-input standard type.

When using NAND gate ICs, each unwanted gate should be disabled by shorting all of its inputs together and tying them to one of the IC's supply lines. In CMOS ICs, the shorted inputs can be wired directly to either supply line, but in TTL ICs, the inputs must be tied directly to the 0V rail, as shown in Figure 21, to give minimum quiescent current consumption with good stability.

Sometimes, when using NAND gate ICs, you may not want to use all of a gate's input terminals. In this case, the unwanted inputs can be disabled by either tying them high (directly in CMOS gates, or via a 1kΩ resistor in TTL types) or by simply shorting them directly to a used input; Figure 22 shows examples of a 3-input TTL NAND gate wired for use as a 2-input type. Note that the fan-in of a TTL NAND gate is an almost constant '1', irrespective of the number of inputs used. Thus, CMOS or TTL AND gates can be converted into simple inverters by simply shorting all of their inputs together; Figure 23 shows examples of TTL AND gates used as simple buffers. Also note that NAND gates are fairly versatile elements, as demonstrated in Figure 24, which shows ways of using 2-input elements to make a 2-input or 3-input AND gate or a 3-input NAND gate.

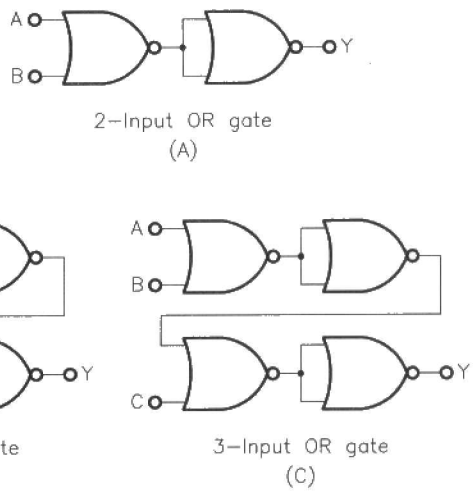
Practical OR Gate IC Circuits

The output of an OR gate goes high when any of its inputs (A *OR* B, etc.) go high. Relatively few OR-gate ICs are available; Figure 25 lists basic details of the six most popular OR-gate ICs; the 74LS32, 74HC32, and 4071B are Quad 2-input types, the 4075B and 74HC4075 are Triple 3-input types, and the 4072B is a Dual 4-input type.

When using OR gate ICs, each unwanted gate should be disabled by shorting all of its inputs together and tying them to one of the IC's supply lines. In CMOS ICs, the shorted inputs can be wired directly to either supply line, but in TTL ICs the inputs must (to give minimum quiescent current consumption with good stability) be tied high via a 1kΩ resistor, as shown in Figure 26.

Note that the fan-in of a TTL NOR gate is directly proportional to the number of inputs used, at a fan-in rate of 1-per-input, and that a TTL 2-input OR gate can be made to act as a simple non-inverting buffer by either tying one input to ground or by tying both inputs together, as shown in Figure 27, but that the buffer has a fan-in of 1 in the former case, and a fan-in of 2 in the latter. Also note that OR gates can be directly cascaded to make a compound OR gate with any desired number of inputs; Figure 28, for example, shows ways of cascading 2-input elements to make OR gates with 3, 4, or 5 inputs.

Figure 33. Ways of using 2-input NOR gates to make various OR and NOR gates.



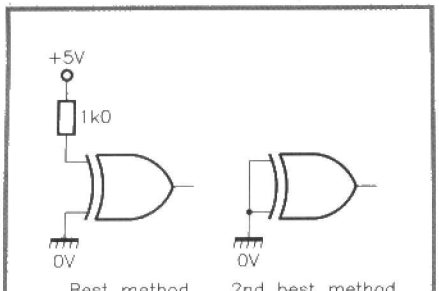


Figure 34. Two ways of disabling unwanted TTL EX-OR gates (see text).

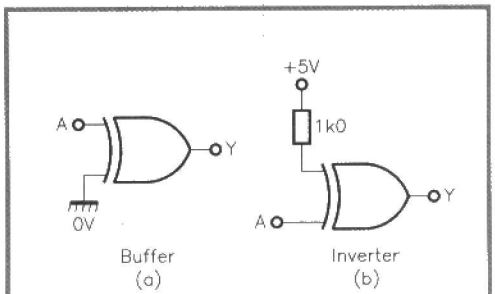


Figure 35. Ways of using TTL EX-OR gates as (a) buffers or (b) inverters.

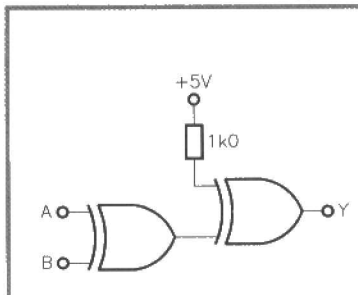


Figure 36. An EX-NOR gate made from two TTL EX-OR gates.

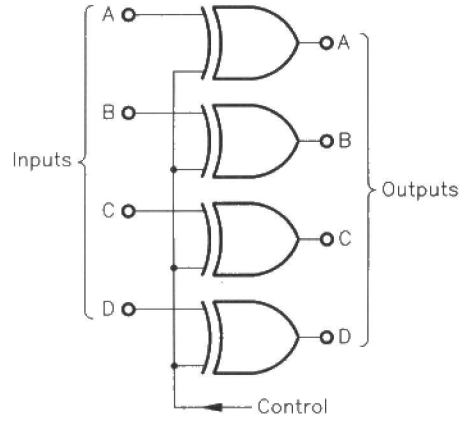


Figure 37. 4-bit True/Complement generator.

1=Inverted output
0=Non-inverted output

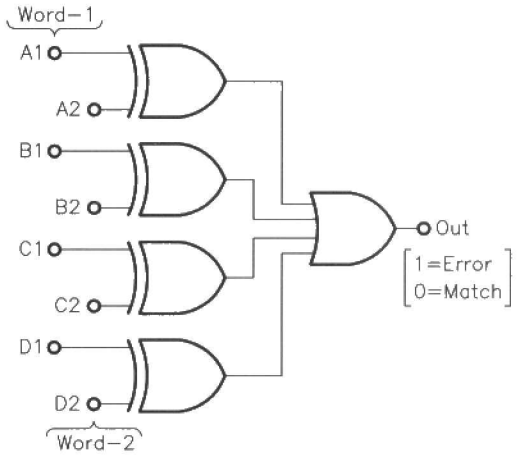


Figure 38. 4-bit logic-state comparator.

Practical NOR Gate IC Circuits

The output of a NOR gate goes low when any of its inputs (A *OR* B, etc.) go high. Figure 29 lists basic details of the ten most popular NOR gate ICs; the 74LS02, 74HC02, and the 4001B and the unbuffered 4001UB are all Quad 2-input types. The 4002B and 74LS260 are Dual 4-input and 5-input types respectively, and the 4025B, 74LS27 and 74HC27 are Triple 3-input types. The 4078B is an 8-input NOR gate IC.

When using NOR gate ICs, each unwanted gate should be disabled by shorting all of its inputs together and tying them to one of the IC's supply lines. In CMOS ICs, the shorted inputs can be wired directly to either supply line, but in TTL ICs the inputs must (to give minimum quiescent current consumption with good stability) be tied directly to the 0V rail, as shown in Figure 30.

Sometimes, when using NOR gate ICs, you may not want to use all of a gate's input terminals. In this case, the unwanted inputs are best disabled by shorting them directly to the 0V rail, as shown in the examples of Figure 31. A NOR gate can be made to act as a simple inverter by either shorting all of its inputs together or by grounding all but one of its inputs; note, however, that the fan-in of a TTL NOR gate is directly proportional to the number of inputs used, so the first method is thus (theoretically) the best, since it offers the lowest fan-in value, as shown in Figure 32. NOR gates are fairly versatile elements, and Figure 33 shows various ways of using 2-input elements to make 2-input or 3-input OR gates or a 3-input NOR gate.

```
0 + 0 = 0
0 + 1 = 1
1 + 0 = 1
1 + 1 = 0, plus carry 1.
```

Figure 39. Basic rules of binary addition.

Practical EX-OR and EX-NOR IC Circuits

The output of an EX-OR gate goes high only when its two inputs are at different logic levels. The most widely used EX-OR gate ICs are the 74LS86 TTL and the 74HC86 and 4070B CMOS Quad types. If one or more of a CMOS EX-OR IC's gates are unwanted, they can be disabled by simply grounding both inputs. In the case of a TTL EX-OR IC, unwanted gates are best disabled by grounding one input terminal and tying the other high via a 1kΩ resistor, as shown in Figure 34, as this results in minimum quiescent current consumption; alternatively, if current consumption is not important, both inputs can be simply tied to ground as shown.

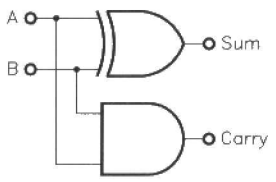
EX-OR gates are reasonably versatile devices. An EX-OR gate can be made to act as a non-inverting buffer by simply grounding its unused input, as shown in Figure 35(a), or as an inverting buffer by tying the unused input high (via a 1kΩ resistor in TTL types), as shown in Figure 35(b). Thus, two EX-OR gates can be used to make a single EX-NOR gate by connecting them as shown in Figure 36, where the right-hand gate is used to invert the output of the left-hand gate (note that Quad EX-NOR CMOS ICs are available in the forms of the 4077B and the 74HC266).

Figures 37 and 38 show two other useful EX-OR gate applications. In Figure 37, four EX-OR gates are fed with a common control signal that enables a 4-bit 'ABCD' input code to be presented in the form of either a true (direct) or complement (inverted) ABCD output, thus making the 4-bit True/Complement outputs available via five (rather than eight) terminals. The circuit in Figure 38 simply compares the logic states of two 4-bit words and gives a logic-0 output if the two words are identical, and a logic-1 output if they differ.

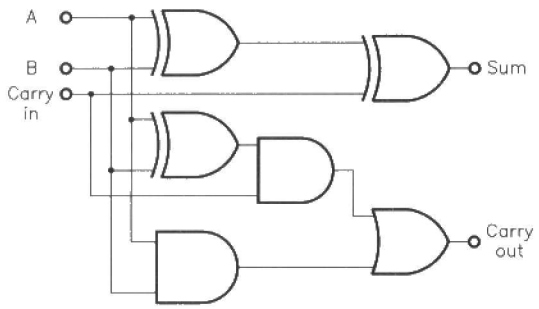
One of the most important applications of the EX-OR gate is as a binary adder. Figure 39 lists the basic rules of binary addition, and Figure 40 shows how an EX-OR and an AND gate can be used to make a practical 'half-adder' circuit that can add two binary inputs together and generate SUM and CARRY outputs. The circuit is called a 'half-adder' because it can perform only a very primitive form of addition that does not enable it to accept a 'carry' input from a previous addition stage. A 'full-adder' is a far more useful circuit that can accept a 'carry' input, perform 2-bit binary addition, and generate a 'carry' output; such circuits are fully cascadable, enabling groups of circuits to perform binary addition on digital numbers of a desired 'bit' size. Figure 41 shows one way of building a 2-bit full-adder circuit, using three EX-OR gates, two AND gates, and an OR gate. In practice, 4-bit full-adders are readily available in the forms of the 74LS283 and 4008B ICs.

Next month digital IC waveform generator circuits are described.

Figure 40. Binary half-adder circuit.

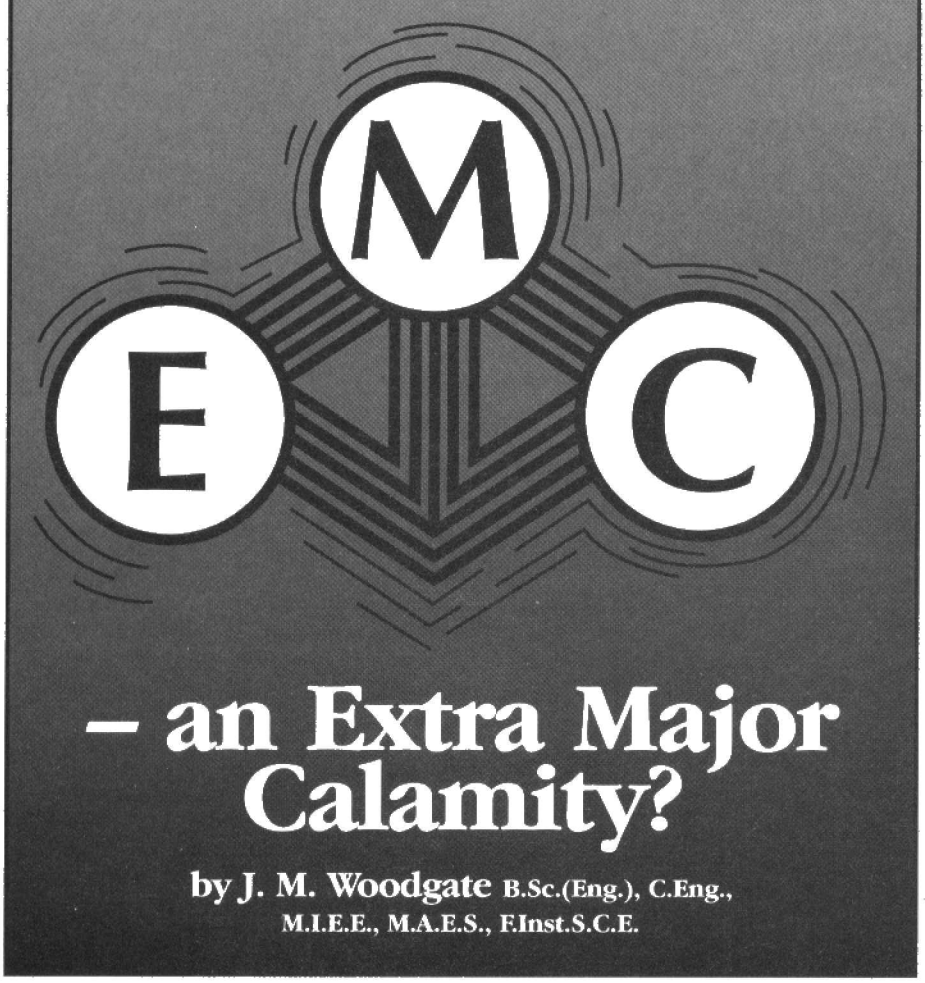


A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1



A	B	Carry In	Sum	Carry Out
0	0	0	0	0
0	1	0	1	0
1	0	0	1	0
1	1	0	0	1
0	0	1	1	0
0	1	1	0	1
1	0	1	0	1
1	1	1	1	1

Figure 41. Full-adder circuit and Truth Table.



– an Extra Major Calamity?

by J. M. Woodgate B.Sc.(Eng.), C.Eng., M.I.E.E., M.A.E.S., F.Inst.S.C.E.

Part 2 – Emissions

For those who missed Part 1 of this series – see *Electronics*, Issue 97 and then read on. EMC (electromagnetic compatibility) is about equipment not emitting electronic interference and not being overly sensitive to anything that is legitimately emitted, such as radio or television transmissions. New legal requirements for EMC (the 'EMC Directive') come into force in Europe on 1st January 1996, but they affect professional electrical and electronics people more than home-constructors. However, the home-constructor must not entirely ignore EMC. For example, home-made gear could interfere with fire or ambulance radio, or even aircraft navigation equipment. More likely, Dr. Jekyll's television next door could be affected, with perhaps immediate physical consequences for the constructor! Furthermore, many electronics professionals read *Electronics*, and I wouldn't want to leave their interests out of consideration.

Emissions

Normally, there are only two paths for emissions from one piece of equipment to reach another. The energy concerned may be conducted through wiring or radiated, either as a magnetic field or as an electromagnetic wave (like a radio transmission). In theory, there could be an electric field emission, but electronic equipment very rarely generates high electric fields, unless specifically designed with that in mind. Clearly, there has to be a general principle that if a piece of equipment is designed to emit something for a useful purpose, the EMC Directive cannot be applied to stop it.

Magnetic field emissions have only short-range effects, and are more likely to interfere with other equipment in the constructor's own possession than anyone else's. An exception to this rule is the Audio Frequency Induction Loop System (AFILS), which was the subject of one of my series some time ago (Issues 39 to 43), where an audio current circulates through a large loop of wire, and the resulting magnetic field can be picked up by hearing aids or special-purpose receivers. In this case, the magnetic field extends at significant strength, relative to the field at the centre of the generating loop, over about four times the loop area (see Figure 5).

'Static'

There is one more emission, which does not normally come from electronic equipment at all, but can wreck it very effectively. This is electrostatic discharge (ESD), or static electricity, and comes from people and the clothes they wear, including shoes. In industrial situations, elaborate precautions against static are essential, and no-one would want to stop a home-constructor wearing an earthed wrist-strap when handling costly CMOS, and especially NMOS, devices. Simple precautions are usually enough. You should avoid clothes and shoes that result in you getting an electric shock when you touch earthed metal objects in the home in winter. Then, if you invariably touch an earthed metal object after you sit down at the bench but before you touch any components, you will be very unlucky if you have any problems with ESD.

Incidentally, 'static' is a very poor name for this effect, because the current pulse produced has a very fast leading edge, and may contain frequencies up to at least 1GHz. The current can be surprisingly large (in excess of 30A) but it lasts for only a very brief period. For example, a human being looks something like a 500pF capacitor in electrical terms, and if charged to 10kV, stores 5μC of electric charge ($Q = CV$, the 'Ohm's Law of Electrostatics'). If the capacitance were discharged via a wet finger at a constant current of 30A, the current would last for 5/30μs, or 167ns. The discharge would not actually be at constant current, but would still be substantially over within 0·5μs. A dry finger would increase that to about 15μs, with correspondingly less current.

Radiated Emissions

There are two ways of launching a self-sustaining electromagnetic wave. One is to create an electric field between two conductors, or between one conductor and earth. This can be called an 'electric antenna', because it produces an initial electric field. One example is a dipole aerial. The other way is to create a magnetic field by allowing a current to flow though a loop or multi-turn coil. This we can call a 'magnetic antenna', and one example is the ferrite rod aerial, although these are used much more for receiving than for sending. Nevertheless, there is a 'principle of reciprocity', which says that what receives also sends, if fed correctly.

The field close to the antenna, whether electric or magnetic, is what is known as an 'induction field', and this extends to a distance from the antenna given approximately by $c/2\pi f$, where c is the speed of light and f is the frequency. Between this distance and $c/2f$, the field changes from almost purely electric

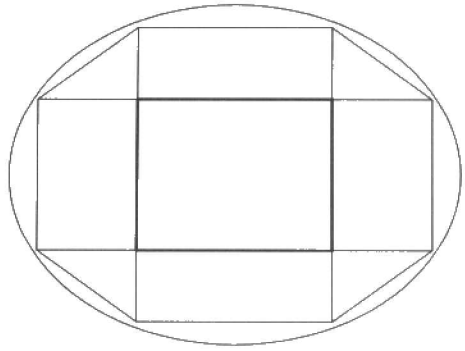


Figure 5. Approximate practical limit of the magnetic field due to a rectangular induction loop. The total area of the rectangles and triangles is four times the area of the central rectangular loop.

or magnetic to an electromagnetic field, travelling outwards from the source with the speed of light. In such a field, the energy is shared equally between electric *(E)* and magnetic *(H)* fields, whose strengths are related by $E/H = 377\Omega$, the 'impedance of free space'. At low frequencies, the volume occupied by the induction field, the 'Fresnel region', is very extensive: even at 1MHz, $c/2\pi f$ is nearly 48m. The rest of the Universe, outside the Fresnel region, is called the 'Fraunhofer region', commemorating another of the physicists who studied optics in the very early days of the nineteenth century.

To have a practicable level of efficiency, an electric antenna must have at least one dimension greater than a quarter of the wavelength of the waves. The physical size of most equipment is too small for it to be an efficient 'electric' radiator below 100MHz, for which a quarter-wavelength is close to 750mm. While there is no equivalent limitation on physical size for a magnetic antenna, the field strength due to a small coil falls off very rapidly with distance, being very nearly inversely proportional to the cube of the distance, so that interference with someone else's equipment is unlikely. For this reason, measurements of radiation are normally not made below about 30MHz.

If your equipment does not contain an oscillator operating at over 1MHz, or high-current switching (say 100mA or more), then radiated emissions are unlikely to be your problem, which is just as well, since they are not easy either to measure or to eliminate. Screening with a substantial metal enclosure (a diecast box, for example) is effective, *but the screening box must be solidly earthed, otherwise it can become the antenna!* Note that it may be much more sensible to enclose only the offending part of the circuit in a box, rather than the whole unit. Wiring leaving the box may well need decoupling capacitors and/or series inductors to prevent it radiating.

It is necessary to regard that 100mA figure with caution, because unexpectedly high currents can occur. For example, the well-known 555 timer chip 'crowbars' (short-circuits) its supply rails when a reset pulse is applied. The resulting current pulse should come from the large capacitor you are advised to connect across the supply rails *close* to the 555, and if you interpret 'close' as 100mm away or 'still in the component box', you have created a loop, extending right back to the reservoir capacitor in the power supply if there is no closer decoupling, in which far more than 100mA may flow in short pulses. In a bad case, the set-up might radiate sufficiently to cause recognisable 'discontinuous interference' (clicks or pops on a radio or TV) even though the timer is reset quite infrequently.

The most common source of discontinuous interference is switching in inductive circuits, because the collapsing current generates a high back emf in the inductance, which usually results in sparks at the switch contacts. The general use of semiconductor devices as switches has much reduced this problem, because the back emf has to be suppressed to prevent it damaging the device. This is done, in the case of DC circuits, by connecting a diode across the inductor, in the correct sense that it is normally reverse-biased. For the back emf, the diode is biased in the conducting direction, and the resulting current dissipates the energy stored in the magnetic field of the inductor as heat in its resistance. In AC circuits, a diode clearly cannot be used, so instead, a series resistance-capacitance network is connected across the switching device. The inductive energy is diverted into charging the capacitor and heating the resistor in series with it, instead of developing a high voltage across the semiconductor device. The resistor is essential, otherwise the inductor and capacitor form a resonant circuit, shock-excited by the back emf, which is exactly how the old spark transmitters worked!

Measuring Radiated Emissions

To do these measurements by the official methods, you need a large flat area of ground where there are no strong RF fields from broadcast or other transmitters. A desert island is ideal, provided it is not below a commercial or military flight-path or near a shipping lane. Then you are supposed to have a special calibrated receiver, called a 'CISPR receiver', one or more calibrated antennas for receiving the emissions, and a ground-plane, with a metal mesh about 10m square as a minimum. However, a good deal of information can be obtained with much less costly facilities. The simplest system is a portable radio, with short-wave reception if you are checking something including an oscillator operating at above 1·6MHz (the upper limit of the medium frequency broadcast band), such as RU53H. Ideally, you do the test in the open air, but a building without too much metal in its structure will do. A ground plane is not essential, but improves repeatability of the tests. It can be made up from galvanised mesh (from agricultural suppliers), the joins being wrapped with bare copper wire and soldered at 300mm intervals. The receiver and the equipment being tested are set up *10m apart*, if possible, and certainly not less than 3m apart, otherwise the results will be fairly meaningless. Obviously, the receiver will pick up lots of radio stations, but the idea is to look for relatively quiet spots in each band and to switch the equipment on and off, or twiddle its knobs, and listen for any audible interference which correlates. Do not forget that the receiver's ferrite rod aerial is directional, so you have to turn the receiver round through at least 90° while listening. Above 3MHz, you should also turn the equipment round, if you have enough patience! If there is an oscillator in the equipment, pay particular attention to its frequency and the lower harmonics, especially the odd-order ones if it is a digital oscillator with a square-wave output. If you cannot hear anything in this test, it is most likely that no-one else will, either, so the equipment is not actually causing any interference, whether it precisely meets the legal requirements or not.

The next step up is to use a receiver such as CM23A, or a scanner, with a field strength meter. With luck, this will give some idea of how much you have reduced an emission, when, having found it, you develop a modification to reduce it. Then, if you have a receiver which can be switched to manual gain control instead of automatic gain control (AGC), you could measure the audio output of the receiver with a CCIR 468-4 weighting filter and quasi-peak meter, which is the same as the quasi-peak meter in the CISPR receiver, and set the IF bandwidth to 9kHz, also to match the CISPR receiver. Even this is not close enough to the official method to give comparable results, but it is certainly quite useful for comparative purposes.

It is possible to use a spectrum analyser instead of a receiver to analyse emissions, and there are several commercial kits of EMC test gear which are based on a spectrum analyser. However, these are costly instruments, beyond most home-constructors and not a few professionals. Furthermore, the results need quite a lot of interpretation to form any sort of correlation with the official emission limits. Where a spectrum analyser is very useful, is in quickly tracking down sources of emission in complex equipment, using 'near-field probes'. This is a fancy name for two rather simple devices that anyone can make. An electric near-field probe is simply about 50mm of 1mm insulated copper wire connected to the centre conductor of a BNC connector, which plugs into the analyser's coaxial input lead. A magnetic near-field probe is a coil of about three turns, 10mm in diameter, of 1mm insulated copper wire, connected between the inner and outer of a BNC connector. You wave these about over the PC boards and cables, to see what they pick up. It is much quicker than using a receiver, because the whole frequency spectrum from 150kHz to 1GHz or more, could be visible at once. But with such a wide sweep, it is easy to miss even a very strong narrow-band emission, so it is advisable to scan in narrower bands. Note that both of these probes have a response basically proportional to frequency, so that quite weak pick-up at low frequencies may be significant. But these are the frequencies at which it is fairly easy to check with a simple receiver.

Conducted Emissions

These can be much more troublesome, because the frequency range can extend from DC to light, and there can be a wide variety of effects. The primary concern is for emissions conducted through the mains lead, because once these get into the public electricity supply system, they can go anywhere, and Murphy's Law indicates that they will probably home in on Dr. Jekyll.

At low frequencies, there are three matters to consider: DC, mains harmonics and flicker. There is only one answer to the DC question – do NOT use half-wave rectification directly from the mains. This does not necessarily exclude use of the low-voltage power supply circuits seen in some low-cost lighting control equipment, for example, where there is a large resistance or a capacitor in series with the rectifier, but these are generally *very dangerous* for home constructors to use. Mains harmonics are most unlikely to trouble the home constructor, because it is the cumulative effect of the harmonics emitted by millions of pieces of equipment which matters. For professional readers, this subject was discussed in Part 1 of this series, and in 'Mains Operated Linear DC Power Supplies' Part Two, *Electronics* Issue 49. The idea is to aim for a rectifier conduction angle of 65° or more, which does reduce efficiency from the highest obtainable, but not dramatically. It should be noted that to measure the mains harmonic currents accurately, you need a low-distortion 50Hz mains supply, with a source impedance of $0{\cdot}4 + j0{\cdot}25\Omega$, i.e., equivalent to a $0{\cdot}4\Omega$ resistor in series with a 796μH inductor.

If you look at your mains voltage waveform

(carefully!), you will almost certainly find that it is not sinusoidal, but has flat tops. These are actually caused by the current pulse loads of so many electronic equipment power supplies, and are evidence for the need to control the amount of harmonic current injection. The effects of this peak-flattening are to increase the conduction angle, but because the current pulse waveform is altered, this increase does not reduce the harmonic current amplitudes, as it does if the input voltage waveform to the rectifier is not flattened other than by the effect of the transformer winding resistances. In fact, the amplitudes of some higher harmonics, such as the ninth and eleventh, may well be increased so much that the equipment *appears* not to meet the limits. There is scope here for a low-cost supply derived from one of the Maplin high-power audio amplifier kits, modified to include the output transformer (necessary for 230 or 240V output) within a feedback loop to set the output impedance to the necessary value, and with the addition of a 50Hz low-distortion oscillator module to drive it. This could also provide a 60Hz supply if one is needed for work on export equipment.

The situation is quite different with flicker. This easily propagates down the street, and will inevitably annoy the neighbours. It would annoy you, if the source was someone else's gear. It is caused by rapidly varying the load on the mains supply, and perhaps the most likely piece of home-constructed gear to cause it is a high-power disco 'chaser' – a box of say, 350 or 500W coloured lamps with an electronic controller that can make them flash on and off in various sequences. Flicker is likely to be much less of a problem, but may not be eliminated, if the lamp circuits are switched at the zero-crossings of the mains supply voltage waveform, which means including something like the SL441CDP zero voltage switch (DB53H) in the control circuits. Flicker measurement requires at least a storage oscilloscope and probably a complex and costly 'standards flicker meter'. However, the method of measurement is based on the sensitivity to flicker of an ordinary 60W mains lamp, so you can easily do a practical check. The lamp should not be on the same circuit as the equipment you are testing, but on another circuit connected to the same main busbars. For example, at home, the equipment would be on a ring-main, while the lamp would be on a lighting circuit. While the official requirements in the standard EN61000-3-3 are quite complex, a single flicker when the equipment is switched on *may* be acceptable, but if the lamp visibly flickers while the equipment is running, you have a problem (or an opportunity to make a significant improvement).

Digital circuits can impress all sorts of high-frequency trash on to the mains lead, and every other lead attached to the equipment as well. A filtered mains input connector (KR99H or KC00A, or the chassis-mounting KR96E, 97F and 98G series), *of the appropriate design and connected as the manufacturer recommends*, is usually effective, and can provide a much quicker solution than obtaining the special capacitors and inductors to build your own, or trying to eliminate the coupling between the digital circuits and the mains lead at source. This coupling often arises from poor PCB design, with long, separated supply lines and no ground plane. The general principle for digital PCB design is to consider *the whole of every current path, from supply line back, via the 0V line to the supply line*, and then to make sure that the path is as short as possible, and does not share any conductor or track unnecessarily with any other path. For analogue boards, the same principle applies, but it may be rather less clear where the current paths should run. In particular, it is all too easy to arrange the earthing in such a way that currents share paths through earth conductors, cable screens or metalwork. This also adversely affects immunity, so we will postpone further detailed consideration.

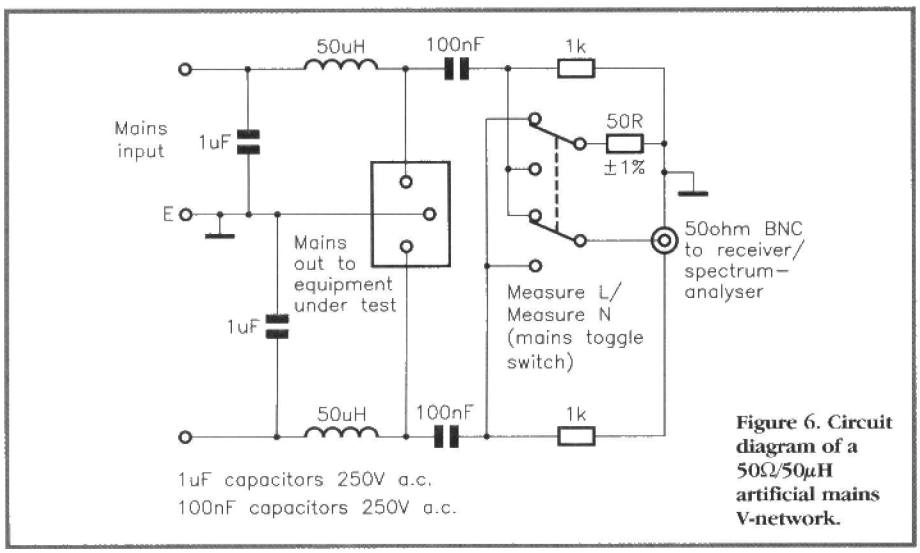


Figure 6. Circuit diagram of a 50Ω/50μH artificial mains V-network.

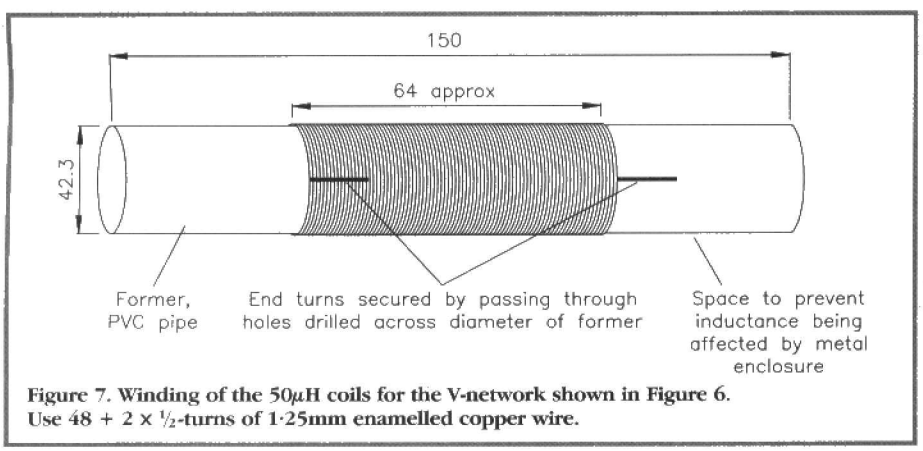

150
64 approx
42.3
Former, PVC pipe
End turns secured by passing through holes drilled across diameter of former
Space to prevent inductance being affected by metal enclosure

Figure 7. Winding of the 50μH coils for the V-network shown in Figure 6. Use 48 + 2 x ½-turns of 1·25mm enamelled copper wire.

Measurement of Conducted Emissions

Once again, the official method requires a CISPR receiver, but for comparative tests, any receiver with provision for connecting an external antenna will do. One more item is required – an 'artificial mains network'. There are different versions of this device for different frequency ranges, but for the 150kHz to 30MHz range, the 50Ω/50μH network shown in Figure 6 is used. This can certainly be home-made, but *because it works at mains voltage it must be carefully made and used.* In particular:

The capacitors must be rated at 250V AC (not DC!) minimum, e.g., JR34M and JR37S.

- Because of the high leakage current through the 1μF capacitor from line to earth (75mA at 240V), the unit MUST be solidly earthed.
- Do not connect the coaxial cable to the BNC connector of the AMN until everything else is switched on and working. In particular, this ensures that any initial surge through the 100nF output coupling capacitor flows through the 1kΩ bleed resistor and not through the sensitive input circuits of the receiver, or even worse, spectrum analyser!

The 50μH inductors can be made up as shown in Figure 7, and the input filter can be one of the KR96/97/98 types, depending on the current rating required, although there seems to be no reason not to use the 10A rated KR98G, since the price is the same for all. The AMN allows the emissions on the live and neutral wires to be separately listened to, and measured or spectrum-analysed if you have the appropriate equipment. Usually, the two emissions are much the same: the emission component which is common to both is called the 'common-mode' signal, while the difference between the two emissions is the 'differential-mode' signal.

A similar 'no effect' criterion can be applied to conducted emissions as for radiated emissions, in that if the equipment doesn't cause interference on your own receiver, it probably won't cause interference anywhere else. But for this practical test, you should use a cheap and cheerful receiver, because more sophisticated designs may well have mains input filters, specifically to eliminate conducted interference.

Next Time

Well, clearly it has to be immunity next time. This can be a good deal more complicated at the practical level, and many home-constructors won't want to bother with it – until they run into an immunity problem!

@Internet

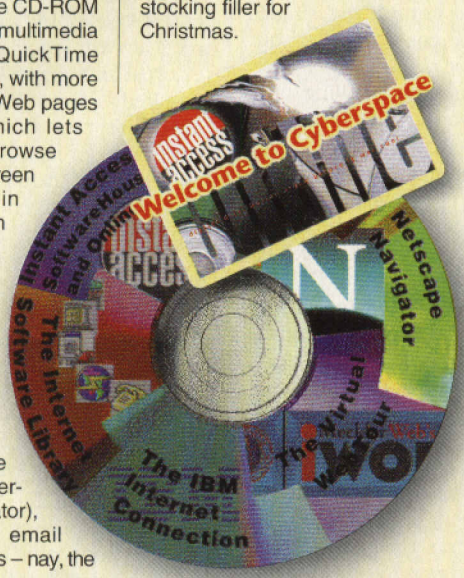
Socks off, you lot!

If you read this column each month, but haven't yet plucked up courage to dip your toes into the Internet paddling pool (let alone surf its ocean waves) then we have news of a product which might help you stop dithering.

Instant Access to Internet is a CD-ROM which contains all the software you need to take the plunge. What's more, the CD-ROM includes an interactive multimedia tour (comprising live QuickTime video clips and graphics, with more than 2000 World Wide Web pages directly viewable) which lets you experiment and browse a virtual Internet on-screen without a surf-board in sight. You don't even need a modem to find out whether the Internet can be of any use to you, just a PC with a CD-ROM drive.

Once you've decided the real Internet's for you, the CD-ROM contains all the software you need for World Wide Web browsing (a full version of Netscape Navigator), sending and receiving email (Eudora Light; the world's – nay, the universe's – best emailer), and in-built connection to IBM's Global Network with one month's free trial. At this point, of course, you do need a modem. The CD-ROM guides you right through the login procedure and gets you up-and-running within just a few minutes.

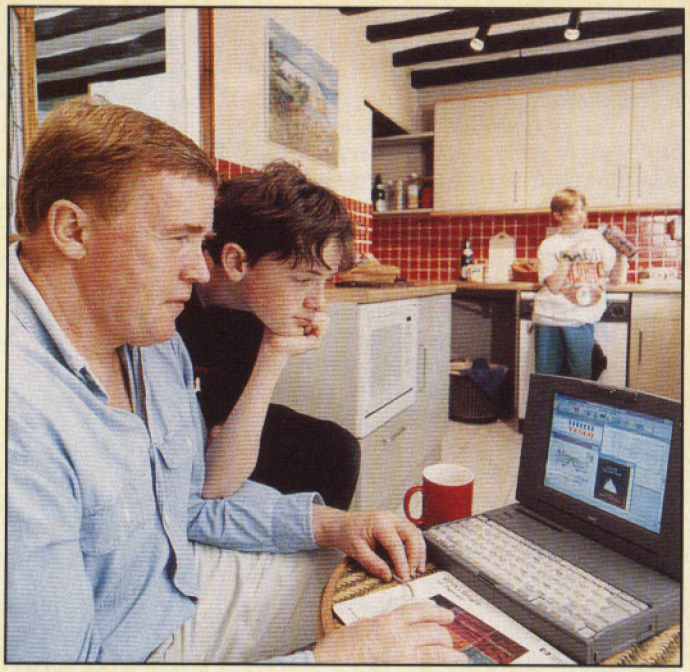
If all this wasn't enough, the CD-ROM has a price tag of only £24.99. Talk about a last-minute stocking filler for Christmas.



Internet Now Available in the High Street

UK Online plans to enable even more people to get surfing the Net by offering its service in the High Street. The company has secured distribution of a unique ready-made 'off-the-shelf' package for under £10 via consumer electronics giant, Dixons Stores Group. This will be the first time in the UK that access to the Internet and online services has been available as a packaged product from a British online service provider. The UK Online packages will be available in 270 stores across the Dixons Stores Group, including Currys, PC World, The Link and Dixons.

Contact: UK Online, Tel: (01749) 333313.



Virtual Shopping a Reality in the UK

Shopping is due to change out of all recognition as we move towards the new millennium, according to the research group, Inteco. 'Virtual' shopping, where we will all be able to order goods off either a TV or PC screen and, in many cases, even have the goods we buy delivered digitally, will have the kind of impact on our shopping habits and retailing in the High Street, that supermarkets have had in the recent past.

"Some people will find virtual shopping more convenient and at least as enjoyable as going out to the shops", said Graham Taylor, manager of the Inteco survey. "Multimedia technology will allow stimulating virtual shopping environments to be created in the home, with interactive TV and multimedia PCs offering attractive product displays, using interactive audio and video to add excitement and endorsement."

The impact of virtual shopping on the UK's £163,400 consumer shopping patterns will be "as though a bomb has hit the High Street", he said, adding that it could even threaten the position of London as the world's financial centre.

"The basic on-line shopping services launched recently by Barclays Bank, Dixons, Tesco, Sainsburys and other leading UK retailers don't yet deliver the full benefits of virtual shopping to the consumer. At present, they charge full retail prices, add extra charges for home delivery and are vague about when they will deliver", Taylor said.

"New home-shopping service operators, not encumbered by the cost of retail premises and telesales staff, will start a war on price and delivery, moving competition between retail and direct selling into a whole new phase", he added.

Contact: Inteco, Tel: (01483) 751777.

Madonna Site Debuts on the World Wide Web

A new Internet site exclusively devoted to Madonna at **http:// www.wbr.com/madonna** has been launched in conjunction with her recent album, *'Something to Remember'*. The site is among one of the first to utilise the new Real Audio 2.0 technology, which will enable fans to automatically hear music on demand, as opposed to a lengthy downloading process.

The Madonna site currently contains details of all of the songs featured on the new album and includes music for each track, video clips, a photo gallery, media information and anecdotes relating to each individual song. An e-mail box has also been created, where fans can send messages direct to Madonna.

Welcome to Madonna - Something To Remember
File Edit View Go Bookmarks Options Directory Help
Location: http://www.wbr.com/mad/index.html
Welcome What's New! What's Cool! Questions Net Search Net Directory
SOMETHING TO REMEMBER

UK Homes Join the Information Superhighway

UK homes are joining the information superhighway with enthusiasm, according to new research by market information company, GfK Marketing Services. The research shows that currently, each week, an estimated 1,300 households subscribe to the Internet. Over 200,000 respondents are expecting to subscribe to the Internet in the next year. The take-up rate is therefore expected to more than treble in the next 12 months, to reach nearly 4,000 new subscribers every week.

When looking at the type of activities carried out using the Internet, the vast majority of respondents (66%) said that they used it mainly for e-mail, and to access business information (56%). Purchasing goods and services came low down the list, with only 6% of respondents admitting to having shopped on the Internet.

Contact: GfK Marketing Services, Tel: (01932) 354911.

Trojan Virus Hits America Online

A new Trojan horse has shown up on America Online and may also be lurking on other online services. The culprit is a file called, variously, 'AOLGOLD', and 'install.exe'. It is sent as a file attached to e-mail, and must be downloaded and executed before it causes harm.

Once the program is downloaded and the computer is rebooted, the program creates a virus.bat batch file that deletes all the files on the hard drive. According to AOL, the virus is not in any of the public areas, and is thought to be spread solely by e-mail. AOL is advising users not to download attached files from an unknown sender.

Contact: America Online, +1 703 556 3746.

CIX and CompuServe Internet Client Combined

Virtual Access is an offline navigator from Ashmount Research, capable of accessing both CIX and Compu Serve. Users are presented with almost identical screens, irrespective of which service is used.

Contact: Ashmount Research, Tel: (0171) 831 4000.

Knock Me Down with a Web

Last month we took a look at Web search engines, showing how they can be used by ordinary users of the Internet to locate information rapidly and accurately. We noted though that other types of Web engines were available. This month we see how Web engines can be made to perform control tasks, and exactly because they are Web engines this means that control is remote. You could be on the other side of the laboratory where the engine sits on another computer – connected to the robotic device in question, or you could be on the other side of the world connected only to the Internet. Look in Site Survey for the sorts of thing we mean. Of course, sites like these are really just the start of what's to come. These are more-or-less open-access sites, allowing anyone with an Internet connection and a Web browser to control the remote device's movements; but it's not difficult to imagine sites which allow only closed access. For scientific and business purposes these could find many, many uses. Taken to the extreme though, when you're winding your way back along the busy roads from office to home, you could get in touch with your home robot and tell it to put the dinner in the oven, uncork a bottle of decent wine, put the dog out, or turn on the electric blanket. Alternatively, you could just get a mobile 'phone and tell your spouse instead.

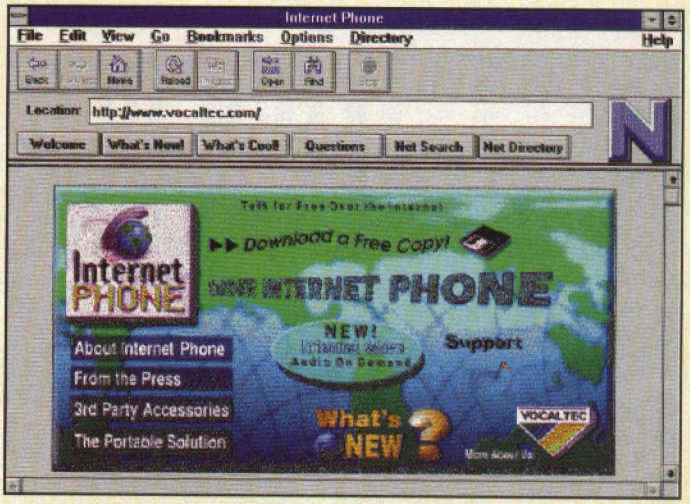
Cyber-Lobbying First

Immediately after the Chancellor of the Exchequer announced a rise in tobacco tax in his budget, on-line smokers were able to send a petition direct by the Internet, asking for fairer taxation on cigarettes.

Is this the first example of cyber-lobbying in this country? Has electronic democracy arrived? When the site is accessed at **http://fairtax.sreact.co.uk**, aside from registering a protest, smokers can see how much tobacco tax has been paid so far this year. The amount goes up as you view, at a rate of £17,000 a minute.

Internet Telephone Service

Internet service provider, Global, intends to launch a full-blown Internet telephone service, despite confusion over the legality of using the Internet for two-way voice conversations. Manufacturer VocalTec claims that Global users equipped with its new Iphone software will be able to make international calls for the price of a local call. This obviously has huge implications for PTTs such as BT. To date, BT has been wary in its responses to voice over the internet, questioning the quality of such services. VocalTec insists the audio quality which its software enables is excellent. According to industry analysts, both OFTEL and Vodaphone are keeping the situation under review. A 60-second downloadable sample of Iphone is available free at **http://www.vocaltec.com**



Site Survey

The month's destinations

Remote control Web engines are popping up at various places around the Internet, and one of the best is the University of Western Australia's Telerobot, at: **http://telerobot.mech.uwa.edu.au/**

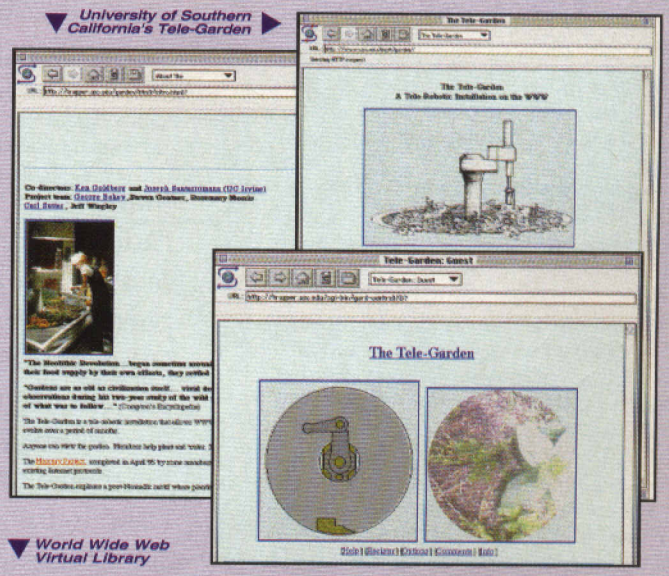
Think of the fact that you're just about as far away from this robot as you possibly get while actually resident on the planet and it really gives you a thrill to be in control. True, you cannot do an awful lot with the thing except to move its arm to pick up blocks and the like, and it is dreafully slow, but remember – it's the principle of the thing you're doing and, what the heck – it's fun.

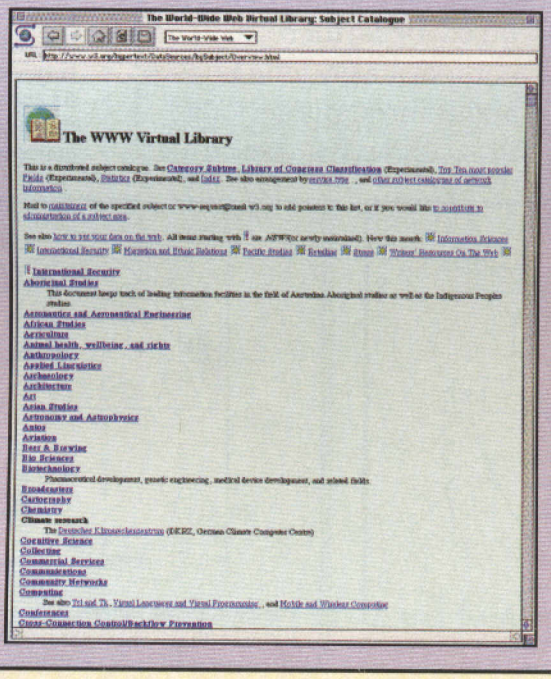
If you're into gardening try the University of Southern California's Tele-Garden at: **http://www.usc.edu/dept/garden/** where you can view robotic control taking place in a real live garden. Members of the research project have full control over the robotic gardener, and guests can log on too for limited control. The Tele-Garden is an offshoot of the Mercury project which was an older robotic control Web engine project to excavate a real archealogical site. The Mercury project concluded earlier this year, but the Tele-Garden is expected to last for several months yet and should be only the first in a series of similar projects.

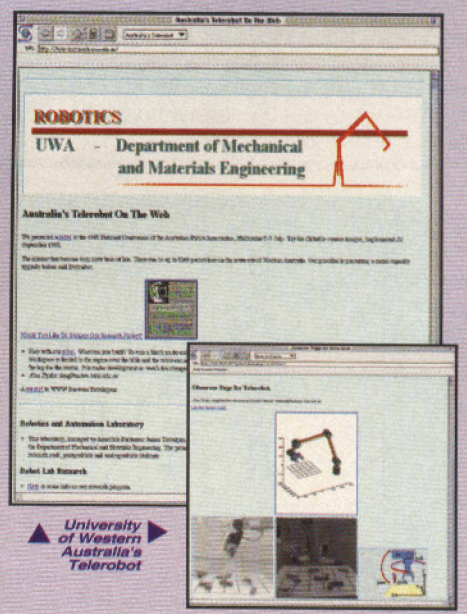
Closer to home, the University of Bradford has a robotic telescope which you can access by way of the University's home page at: **http://www.brad.ac.uk/** where you'll find a hyperlink. At the time of writing we couldn't access the telescope, so no piccies we're sorry to say.

Finally, if it's pure information you're after, take a trip to the World Wide Web Virtual Library, situated at: **http://www.w3.org/hypertext/DataSources/bySubject/Overview.html**

It is a fantastic collection of links to information about books in print.






ROBOTICS
UWA – Department of Mechanical and Materials Engineering
Australia's Telerobot On The Web
University of Western Australia's Telerobot

What are Phase-Locked Loops?

by Ian Poole

Many Hi-Fi tuners and radios quote PLL Quartz or PLL Synthesised as part of their specification. Other radios may advertise the use of PLL technology or a Phase-Locked Loop for their FM discriminator. Despite the widespread use of these advertising buzzwords, there is comparatively little known about these mysterious PLLs and what they are.

PLL stands for Phase-Locked Loop. It is a form of servo loop or circuit which uses negative feedback principles. By using these, a basic PLL locks the frequency of its own internal oscillator onto the frequency of an incoming signal. Whilst at first sight, this may not appear to be very useful, a little ingenuity enables PLLs to be used as frequency synthesisers for generating radio frequency signals, in FM discriminators, in the colour decoding stage in televisions, and in a wide range of other applications.

The operation of the PLL hinges around minimising the phase difference between two signals. Therefore, it is necessary to take a brief look at what phase and phase differences are.

What is Phase?

A radio signal can be represented by the familiar sine wave shape. It receives its name from the fact that it is a plot of the value of sine as the angle increases, as shown in Figure 1. As the angle increases, the value oscillates above and then below the line. Then as the value reaches 360°, the process starts over again as if the angle had reverted to 0°. This means that for any point on the cycle where the angle is known, a corresponding value can be calculated.

The next concept of interest to PLL designers is that of phase difference. Take the example of the two signals shown in Figure 2. Although the two signals have the same frequency, the peaks and troughs do not occur in the same place; there is said to be a phase difference between the two signals. This phase difference is measured as the angle between them. As shown in the diagram, it can be seen that it is the angle between the same point on the two waveforms. In this case, a zero crossing point has been taken, but any point will suffice provided that it is the same on both.

When there are two signals having different frequencies, it is found that the phase difference between the two signals is always varying. In fact, a definition of two signals having exactly the same frequency is that the phase difference between them is constant. There may be a phase difference

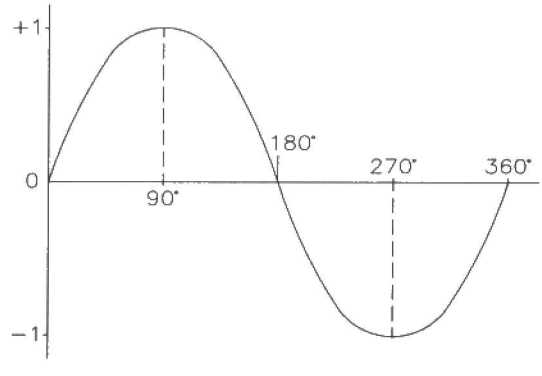


Figure 1. A sinusoidal (sine) wave.

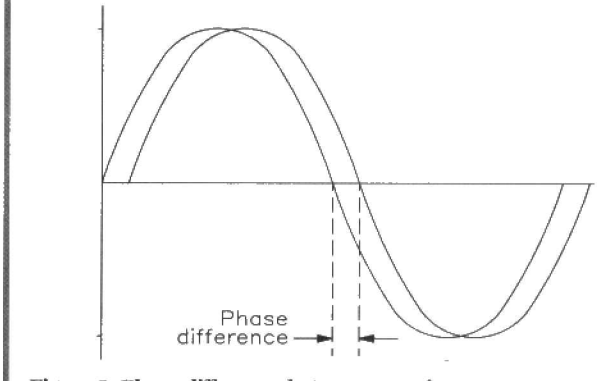


Figure 2. Phase difference between two sine waves with the same frequency.

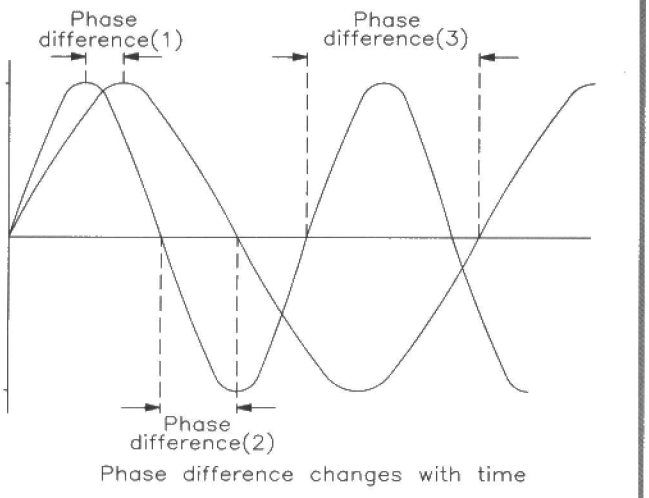


Figure 3. Phase difference of two signals with different frequencies.

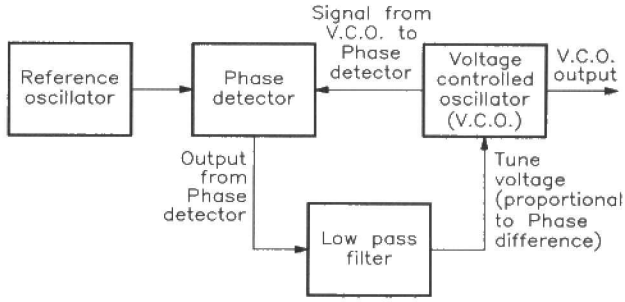


Figure 4. Basic phase-locked loop (PLL).

between the two signals, as shown in Figure 3. This only means that they do not reach the same point on the waveform at the same time. If the phase difference is fixed, it means that one is lagging behind or leading the other signal by the same amount, i.e. they are on the same frequency.

PLL Basics

The phase-locked loop consists of three main building blocks, namely, a voltage controlled oscillator (VCO), filter (possibly with an amplifier), and a phase detector or phase comparator. These are connected together, as shown in Figure 4. A reference oscillator is shown in the diagram to help explain the operation, but it is not actually part of the loop itself. Although the mathematics behind phase-locked loops can become very complicated, their basic operation is quite easy to understand from a qualitative view.

The voltage controlled oscillator produces a signal which enters the phase detector. Here, the phase of the signals from the VCO and the incoming reference signal are compared, and a resulting difference or error voltage is produced. This corresponds to the phase difference between the two signals. This error signal passes through a low-pass filter which governs many of the properties of the loop and removes any high frequency elements on the signal. Once through the filter, the error signal is applied to the control terminal of the VCO as its tuning voltage. The sense of any change in this voltage is such that it tries to reduce the phase difference and hence, the frequency between the two signals.

When the loop is in lock, a steady state error voltage is produced. By using an amplifier between the phase detector and the VCO, the actual error between the signals can be reduced to very small levels. However, some voltage must always be present at the control terminal of the VCO, as this is what puts it onto the correct frequency.

The fact that a steady error voltage is present means that the phase difference between the reference signal and the VCO is not changing. As the phase between these two signals is not changing, it means that the two signals are on *exactly* the same frequency.

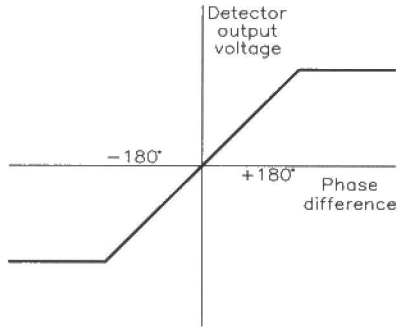


Figure 6. Output characteristic of a phase-frequency detector.

Phase Detector

There are two main types of phase detector. The simplest is a straightforward mixer. As its output corresponds to the multiple of the two signals at any instant, this output is also proportional to the phase difference between the signals. Whilst this type of detector sounds ideal, it is a type known as 'phase sensitive', and this can lead to various problems when the loop is trying to lock.

To illustrate this, take the case when the loop is not in lock. It is quite likely that the frequency of the reference signal and the VCO differ by quite a large amount. When these two signals are passed into the phase detector, two signals will be produced. One is equal to the difference frequency, and the other is equal to the sum. The difference frequency product is the one used to give the phase difference. It is quite possible that the difference frequency signal will fall outside the pass-band of the loop filter. If this occurs, then no error voltage will be fed back to the VCO to bring it into lock. This means that there is a limited range over which the loop can be brought into lock, and this is called the capture range. Once in lock, the loop can generally be pulled over a much wider frequency band.

To overcome this problem, the oscillator must be steered close to the reference

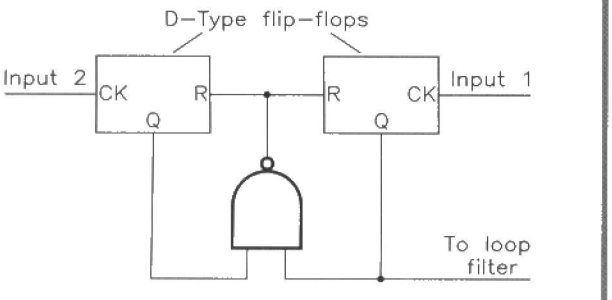


Figure 5. A dual D-type phase detector.

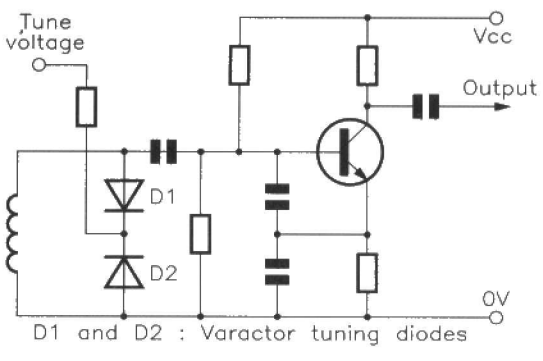


Figure 7. Colpitts oscillator for use in a synthesizer or phase-locked loop.

oscillator frequency. This can be achieved in a number of ways. One is to reduce the tuning range of the oscillator, so that the difference product will always fall within the pass-band of the loop filter. In other instances, another tune voltage can be combined with the feedback from the loop, to ensure that the oscillator is in the correct region. This approach is often adopted in microprocessor systems, where the correct voltage can be calculated for any given circumstance.

Another form of detector is said to be phase-frequency sensitive. There are a number of circuits which can be used, but they use digital circuit techniques. Integrated circuits like the 74HC4046 (UF03D) or HCF4046 (QW32K) are examples of fully integrated detectors. Sometimes, it is necessary to make discrete versions, and one popular circuit is a dual D-type detector, which is shown in Figure 5. These circuits have the advantage that whilst the phase difference is between ±180°, a voltage proportional to the phase difference is given. Beyond this, the circuit limits at one of the extremes, as shown in Figure 6. In this way, no AC component is produced when the loop is out of lock, and the output from the phase detector can pass through the filter to bring the loop into lock.

Loop Filter

The design of the loop filter is crucial to the operation of the whole loop. The choice of the circuit values here is usually a very carefully balanced compromise between a number of conflicting requirements.

The filter is needed to remove any unwanted high-frequency components which might pass out of the phase detector and appear in the VCO tune line. They would then appear on the output of the VCO as spurious signals. To show how this happens, take the case when a mixer is used as a phase detector. When the loop is in lock, the mixer will produce two signals: the sum and difference frequencies. As the two signals entering the phase detector have the same frequency, the difference frequency is zero and a DC voltage is produced, proportional to the phase difference as expected. The sum frequency is also produced, and this will fall at a point equal to twice the frequency of the reference. If this signal is not attenuated, it will reach the control voltage input to the VCO and give rise to spurious signals. When other types of phase detector are used, similar spurious signals can be produced and the filter is needed to remove them.

The filter also affects the ability of the loop to change frequencies quickly. If the filter has a very low cutoff frequency, then the changes in tune voltage will only take place slowly, and the VCO will not be able to change its frequency as fast. This is because a filter with a low cutoff frequency will only let low frequencies through, and these correspond to slow changes in voltage level.

Conversely, a filter with a higher cutoff frequency will enable the changes to happen faster. However, when using filters with high cutoff frequencies, care must be taken to ensure that unwanted frequencies are not passed along the tune line with the result that spurious signals are generated. The loop filter also governs the stability of the loop. If the filter is not designed correctly, then oscillations can build up around the loop, and large signals will appear on the tune line. This will result in the VCO being forced to sweep over wide bands of frequencies. The proper design of the filter will ensure that this cannot happen under any circumstances.

Voltage Controlled Oscillator (VCO)

In order that the loop can meet its full specification, a well-designed oscillator is essential. Designing a really high-performance oscillator for high frequencies is often more of an art than a science, but for many low-frequency applications, a relatively simple oscillator will produce good results.

The oscillator circuits are based around the standard configurations. A Colpitts configuration like that shown in Figure 7 is favoured in many radio frequency applications. In most respects, it will be virtually the same as one tuned by a mechanical variable tuning capacitor. However, the oscillator for a PLL must be tuned electronically, and this is achieved by the use of a variable capacitance diode. A resistor is included in the tune line to ensure that RF components are not carried back along the tune line. It also prevents the oscillator tuned circuit from being loaded by the drive circuitry for the control voltage. A resistor is often used for this function rather than a choke because it is less likely to cause spurious oscillations. A value around 10kΩ is normally about optimum.

The tuning range of the VCO is of importance. It governs the range over which the loop can operate or remain in lock. This is called the lock range and is often seen in loop specifications and calculations.

With the main building blocks linked up to form a loop, there are many uses which can be found. One popular example of a PLL is the LM565N (WQ56L) which can be used in an FSK modem, tone decoder, wide-band FM discriminator, data synchroniser, and many more applications. Its block diagram is shown in Figure 8.

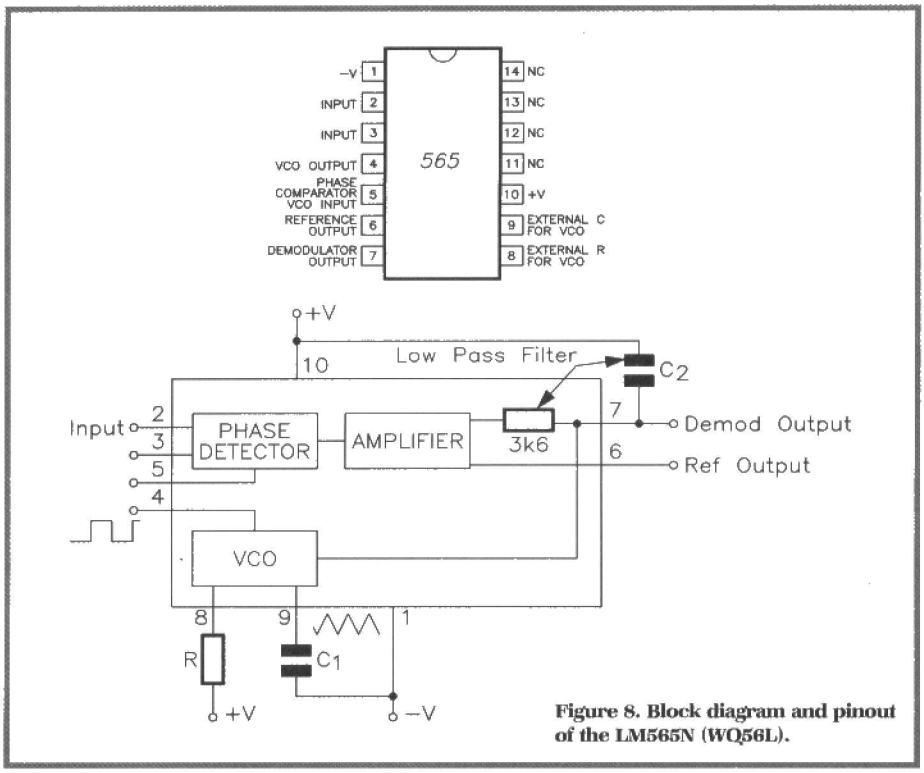


Figure 8. Block diagram and pinout of the LM565N (WQ56L).

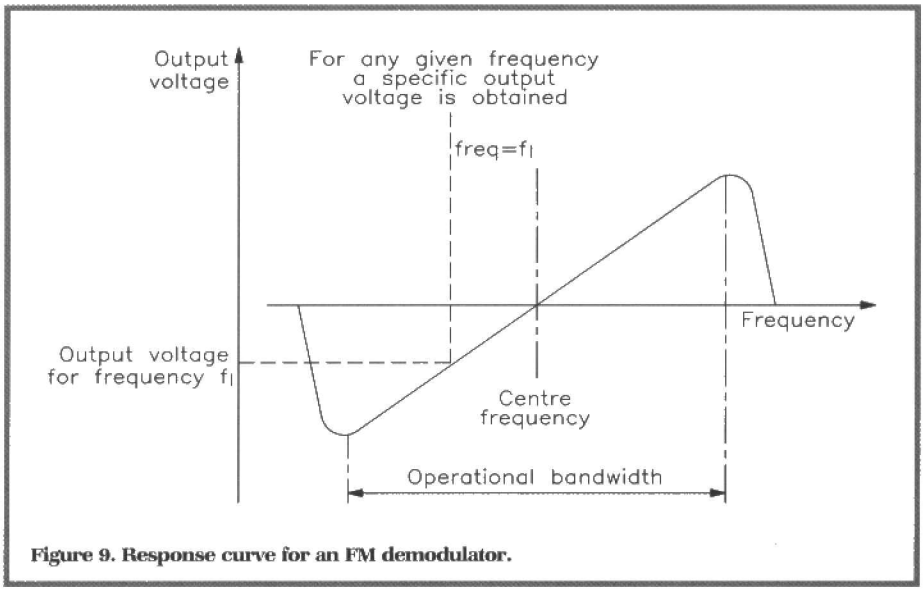


Figure 9. Response curve for an FM demodulator.

FM Discriminator

Phase-locked loops are widely used as FM discriminators or demodulators to regenerate the audio signals from the radio frequency signals coming from the intermediate frequency stages in a radio receiver. A number of circuits exist to perform this function, and for many years, circuits like the Foster-Seeley and ratio detectors were used exclusively. Now that phase-locked loop chips are available they are widely used because of their excellent performance.

To demodulate FM, a characteristic like that shown in Figure 9 is needed. As the frequency changes from the centre, the output should vary accordingly. In this way, the frequency variations are converted from frequency changes to voltage changes.

The way in which the PLL operates as a detector is quite simple. The incoming radio frequency signal from the IF stages of the receiver is applied to the reference input of the phase detector as shown in Figure 10. When no modulation is applied, the loop will be in lock, and if the radio is properly in tune, the carrier will be in the centre of the tune range of the loop. To keep the loop in lock, a certain tune voltage will be required.

When modulation is applied to the carrier, it will swing up and down in line with the audio signal. As this occurs, the loop will try to keep in lock and it will track the signal up and down. In doing this, the tune voltage will have to vary to keep the VCO on the right frequency. It is this tune line signal which is the demodulated audio. It is amplified and passed on to the audio stages for further amplification.

One of the main requirements for FM demodulation is that the frequency to voltage characteristic should be very linear. In this way, the level of distortion will be minimised. In a phase-locked loop detector, the linearity will depend upon the voltage-to-frequency characteristic of the VCO. As it is possible to make a VCO with a linear characteristic the levels of distortion can be made to be very low. The other advantage of a PLL discriminator is that it does not need the use of a tuned transformer like the other designs. As transformers can be relatively expensive, PLLs can often have a cost advantage on this point.

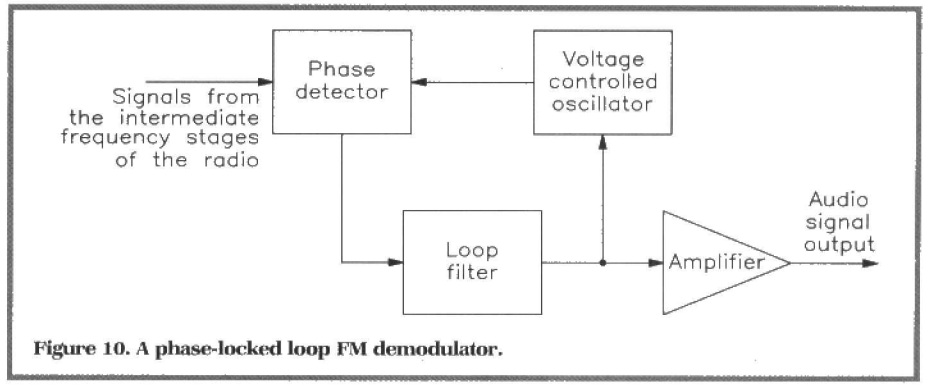


Figure 10. A phase-locked loop FM demodulator.

Frequency Synthesizer

Another very common use for phase-locked loops is in frequency synthesizers. Here, the loop is used to synthesize a radio frequency signal, which is as stable as the crystal oscillator used in the reference. In many analogue receivers using ordinary variable frequency oscillators and a tuning dial, frequency drift can be a real problem, especially on higher frequencies. Often it is necessary to retune the set after a while to keep it on frequency.

The frequency synthesizer is virtually drift-free. In addition to this, synthesizers lend themselves to having their frequencies programmed by digital circuitry, making them ideal for processor controlled sets. In fact, many of today's new sets use synthesizers, enabling facilities like electronic station memories, keyboard frequency entry and so forth, to be included. As a result of these advantages, synthesizers are widely used in modern day receivers and tuners. One example of a synthesizer controlled Hi-Fi tuner is the Velleman K4500 Digital Synthesized FM Tuner (VF20W).

In its basic form, the phase-locked loop just generates a frequency equal to that of the reference. However, more strictly, the action of the loop causes aims to reduce the phase difference between the two signals entering the phase detector. By placing a frequency divider in the loop between the VCO and the detector, the loop locking can be altered.

Take the example when the division ratio is two. For lock to be maintained, the phase difference between the two signals entering the detector must be reduced to zero. However, as the VCO frequency has been divided by two, this means that the VCO must be operating at twice the phase detector or reference frequency. Similarly, if the division ratio is increased to three, the VCO will run at three times the reference frequency for lock to be maintained.

From this, it can be seen that as the division ratio is altered, the VCO will step in increments equal to the reference frequency, assuming that the oscillator can cover the required range. To make the loop step in smaller frequency steps, the reference frequency must be reduced. The easiest way to achieve this is to run the reference oscillator at a convenient frequency, often 1MHz or more, and then divide the frequency using a fixed divider. A programmable divider is then used to make the loop cover the correct range. Also, to ensure that the loop is does not drift, a crystal oscillator is normally used for the reference.

As an example of a synthesizer, take the requirement of a VHF FM tuner having to cover the range 87·5 to 108MHz. Assuming the receiver has an intermediate frequency of 10·7MHz, the local oscillator will have to cover a range of 98·2 to 118·7MHz and ideally, in increments of 50kHz. If a 1MHz reference oscillator is used, a fixed divider of 20 will need to be used to bring the reference down to the phase comparison frequency of 50kHz. Then, to cover the required range, the programmable divider will need to be able to give division ratios of 1,964 (98·2MHz/50kHz) to 2,374 (118·7MHz/50kHz), as shown in Figure 11. Whilst this may seem a very large division ratio, dividers do exist for this purpose, and are commonly used.

Colour Burst Regeneration

Another use of phase-locked loops is in 'storing' or remembering frequencies. One common use for this occurs in colour television signals, where a colour burst signal occurs at the beginning of each line transmitted, as shown in Figure 12. The colour information is carried as a phase difference between the reference and a subcarrier transmitted on top of the ordinary luminance or light intensity signal. An error in phase of the reference oscillator will tend to distort the colour in the picture.

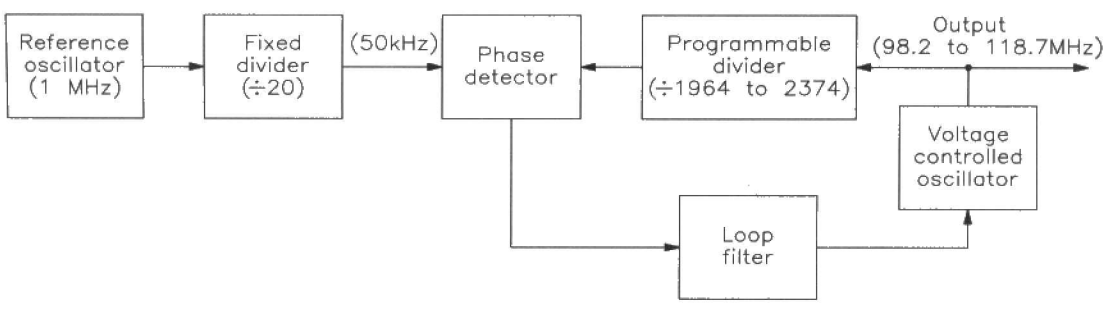


Figure 11. A basic synthesizer.

For the system to operate satisfactorily, a very stable oscillator is needed in the television, and its phase and frequency must correspond exactly with the colour burst signal. To achieve this, a phase-locked loop with a very narrow loop bandwidth is used. During the periods when the colour burst signal is transmitted, the loop will lock onto it. After the colour burst signal has finished, the loop will only drift very slowly, as the loop bandwidth is made exceedingly small. It therefore remembers the frequency and phase until the colour burst signal from the next line. In view of the extreme accuracy required in the loop, a crystal oscillator is normally used for the VCO. In this way, the VCO is on virtually the right frequency and only relatively minor adjustments need to be made to ensure the phase is exactly right.

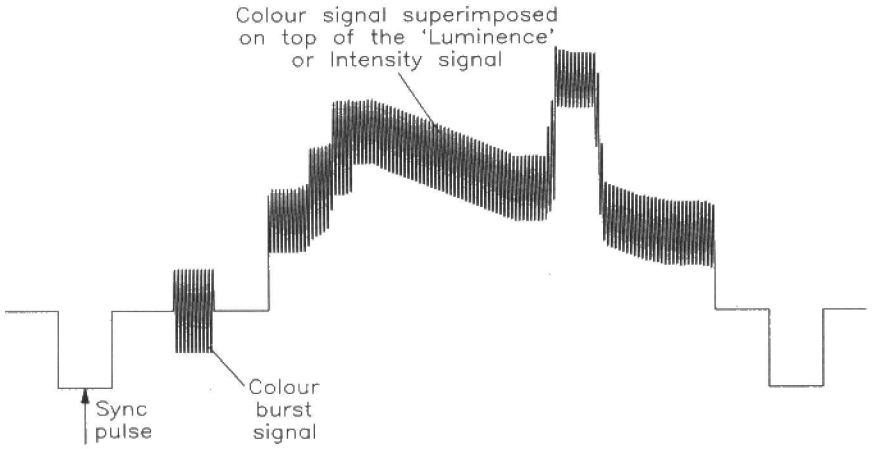


Figure 12. A line from a television signal.

Summary

The phase-locked loop is one of the most versatile building blocks in radio frequency electronics today. Whilst it was not widely used for many years, the advent of the IC meant that phase-locked loop and synthesizer chips became widely available. This made them cheap to use and their advantages could be exploited to the full. Nowadays, most Hi-Fi tuners and car radios use them, as do a large proportion of the portable radios on the market. With their interface to microprocessors being so easy, their use is assured for many years to come.

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Apple Expo 1995 review

by Tracey Walker, David Holt and Jason Hyatt

On a dreary Thursday morning the Maplin DTP department team ventured into the world of the unknown (The Mac Show) . . .

Apple Expo '95, Europe's leading independent Mac industry exhibition, opened its doors once again last November at the Grand Hall, Olympia. The event attracted hundreds of thousands of Mac enthusiasts from all over the country and beyond, including our DTP department team on a mission to seek out new, revolutionary and fun innovations (and also get some freebies!) Here are a few of the most interesting attractions.

Internet Surfing Centre

New users to the internet were able to surf the information superhighway at a special demonstration and internet surf centre, with over fifty user stations, was arranged in association with BT. Apple users were given a presentation about the internet followed by a thirty-minute browsing session on the internet. Preselected web sites were already downloaded showing the wide selection of sites on offer. While this could have been interesting, we found it very slow and quite often couldn't access the sites we wanted to, due to limited user numbers. A bit disappointing.

QuarkXPosure™

Xchange ran the first UK public previews of two forthcoming Quark products – QuarkXPosure and QuarkImmedia – two products which will begin shipping in 1996. QuarkXPosure is an image editing, photo retouching and painting program that is billed as a new rival to Adobe's Photoshop (the current industry standard) incorporating many new features and capabilities, including the ability to delete or modify changes made at any time during the editing process.

QuarkImmedia is a multimedia design system, introduced to enable QuarkXpress users to use their knowledge to branch into multimedia. QuarkImmedia can be used to create projects for CD-ROM, kiosk, Internet and the print market.

Illustrator 6.0™

This was a significant upgrade to the industry's leading illustration and design program for the Macintosh and Power Macintosh. Version 6.0 delivers those features that users have requested most frequently, including inhanced image support, cross-product integration with other Adobe products and built-in production capabilities.

Scanning

As the Maplin pubishing department is in need of a new scanner, we spent a while investigating the new range on show. As usual, we were spoilt for choice with the very large, very expensive, top quality scanners from the likes of Crossfield and Scitex. Very nice, but not really practical for our small department.

By far the most versatile was the Leaf Lumina scanner from Leaf Systems. As well as scanning negatives and transparencies, it can be attached to a tripod to scan large flat artwork, and even takes professional quality still-shot digital photographs straight into the Mac.

Wacom Art Pad

Wacom had some interesting new developments for their pressure-sensitive Artpad II. As easy to use as pen and paper, it's brilliant for those of us who find the mouse a little bit limiting for illustration and drawing. You can control line thickness and colour intensity by pressing harder with the pen, (256 levels of pressure). As if that wasn't good enough, Wacom have now introduced the 'Ultrapen Eraser'; simply turn the pen upside-down to erase mistakes, and it's as sensitive as the pen. The Artpads are now available up to A2 size. We think they're great!

OpenDoc™

An important software breakthrough of the 90s was also previewed *OpenDoc*, which will become available to MacOS users in early 1996 is a new software architecture that will change the way software is developed and used in the future. *OpenDoc* will allow users to customise and simplify the way they work with their applications. It will provide users with the specific tools they need, when they need them – in other words, an end to switching between numerous applications for different tasks.

With *OpenDoc*, users will be able to concentrate on their work, instead of on manipulating multiple applications. It works on the basis of 'component software', a concept that allows users to add or remove components of a program by simply dragging and dropping onto the module being used at the time.

More and more, software developers are adopting the idea of 'component software' when developing new applications – in fact, two-thirds of all software developers stated that they will be building component applications within the next two years (source: *Strategic Focus*).

After *OpenDoc*'s release for MacOS users, IBM will release a beta version of the software which has been developed for Windows '95 and Windows NT platforms. PC users can expect the release during the second quarter of 1996.

Developers who wish to write an *OpenDoc* application for MacOS can e-mail Apple for the information they need to get started. Send an e-mail to: **opendoc@apple.com**

MacOS users can visit the Apple internet homepage for up-to-date information on OpenDoc: **http://www.info.apple.com/opendoc/**

Smart Board

As usual we like to have something to play with at the Mac Show, and this year the most fun was had with the 'Smart Board'. Attached to your computer, anything you draw or write on the 4 × 3in. (102 × 76mm) white board appears on your screen, to be saved and retrieved or printed later. What most impressed us was the colour sensitivity – if we wrote in green, it appeared in green on the screen, and if we rubbed out a line with our finger, it was deleted on the computer. Brilliant.

Printers

There were A1 colour poster printers in abundance at the show, outputting vibrant coloured, top quality prints. In addition to these, Fuji launched their new Colorpix A0 inkjet printer system, capable of outputting posters and banners up to 36 inches wide and 30 metres long, straight from the Mac.

By the end of the day we were ready for a rest, so we made our way to Apple's impressive stand to have a sit down and soak up some information on the new generation Power Macs. Impressed is an understatement. Top of the range comes the Power Macintosh 9500, with the new PowerPC 604 processor, a 2 G-byte hard drive, quad speed CD-ROM, Apple SuperDrive (which enables cross-platform file exchange), built-in 10BaseT and AAUI Ethernet, six PCI slots, 12 DRAM slots for up to 768M-byte RAM, three expansion bays, built-in SCSI, and processor upgradability.

According to independent study by Competitive Assessment Services (CAS) Apple's PowerPC Processor-Based Macintosh Systems are significantly faster than Pentium Systems. In a study Power Macintosh systems outperformed Windows computers based on equivalent clock-speed Pentium processors by up to 44% overall. Not bad.

NEWS Report

UK Bid for Display Leadership

Cambridge Display Technology has announced plans to take its world-beating display technology out of the laboratories and into pilot production, and is launching a campaign to raise £4million in a first-stage venture capital funding. The three-year-old company, which holds the fundamental patents on light-emitting polymers (LEPs) that could revolutionise the multi-billion dollar global display industry, expects to bring its first products into production in 1997.

"We believe that the invention of LEP is as important for the future direction of the displays industry as the discovery of the LCD, which means thinking big from the outset and setting our sights on targets that match the potential", said David Mann, CDT chairman.

The potential for light-emitting polymers is a substantial proportion of the global electronic displays market estimated by analysts Stanford Resources, Inc. at $22·5 billion in 1994, and forecast by the Electronics Industry Association of Japan to go to $45 billion in the year 2000.

"The attractiveness of LEP displays is that they combine high performance with low cost, and can be fabricated on flexible sheets of plastic using well-established and inexpensive manufacturing processes. Very large area, wafer-thin displays of all kinds and shapes can be envisaged", explains Professor Richard Friend, FRS, who is the Cavendish Professor of Physics at Cambridge University, and is also a director of Cambridge Display Technology.

The ultimate prize, is the replacement of CRT for computer displays and even television, but that is some way off and would only happen when the new technology provides the same performance as the CRT at a significantly smaller cost premium than is achieved by existing flat panel technologies such as Active Matrix LCD. In the meantime, there are some big markets already within reach, and Cambridge Display Technology has based its initial marketing strategy on tackling these.

Some of the markets targeted by the company are characterised as 'low information content' displays. A first target, for example, is low-intensity backlights in products such as mobile 'phones, where LEP will be substituted for existing technologies because of its inherent simplicity and cost. Later targets are composite displays with complicated light patterns, where LEPs could replace perhaps 20 components with just one.

In 'high information content' displays, ranging from those for advanced personal digital assistants (PDAs) to computer and video applications, Cambridge Display Technology plans first to exploit newer markets where technologies are not yet entrenched. The company aims to establish leadership in these markets by leveraging the low-cost base with the ease of patterning and addressing. An example could be headsets for virtual reality entertainment.

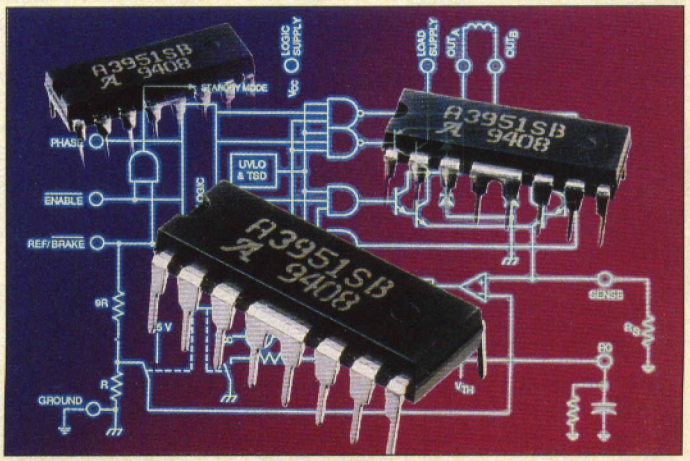
Contact: Cambridge Display Technology, Tel: (01223) 276 351.

Full PWM Motor Driver IC

Allegro MicroSystems has introduced a full-bridged motor-driver integrated circuit, the A3951S, which provides bi-directional pulse width modulated (PWM) current control of DC motors or servomotors with a continuous output current of ±2A and an operating voltage of up to 50V.

The A3951S features internal fixed off-time PWM current-control circuitry, which is used to regulate the maximum load current, with the peak load-current limit being set by a user-selected input reference voltage and external sensing resistor. The fixed off-time pulse duration is set by a user-selected external RC timing network.

Contact: Allegro MicroSystems, Tel: (01932) 235355.



Dr. Soloman Aided Black Baron Conviction

The first-ever jailing of a computer virus writer in November, is a milestone event that should start other virus writers thinking about a new career. Christopher Pile, 26, who dubbed himself the Black Baron, is the first person anywhere in the world jailed for creating and spreading computer viruses.

"Pile got nothing out of the viruses he wrote, except 18 months in prison. The verdict is clear. There is no benefit and much risk to playing with fire. I hope this deters others, so that no-one else gets 18 months", said Dr. Alan Solomon, chairman and founder of S&S Software International, the originator of Dr. Solomon's Anti-virus Toolkit.

Pile created SMEG, a mutation engine named for an expression used in the cult television series, '*Red Dwarf*'. SMEG encrypts viruses, changing them each time they infect a computer, making the viruses harder to find. S&S Software International provided technical assistance to British police investigating the viruses.

Contact: S&S International, Tel: (01296) 318700.

ARM Extends Family with ARM8

Coinciding with its fifth birthday, Advanced RISC Machines (ARM) announced that it is making a powerful extension to the ARM family. The ARM8 architecture will extend ARM's product portfolio by filling the gap between the embeddable ARM7 RISC cores and the very high-performance StrongARM processor.

The ARM8 architecture is aimed at systems which will benefit from a high-performance cached processor, but are still sensitive to system power consumption and cost. According to ARM's CEO Robin Saxby, target applications include high-end mobile-computing, digital TV, second-generation personal digital assistants (PDAs) and multimedia applications.

Most high integration, real-time applications are best addressed by the ARM7TDMI, which, with the 'Thumb' code compression extension, is class-leading in terms of cost, performance and area efficiency. ARM8 will step in where even greater performance is required.

Contact: Advanced RISC Machines, Tel: (01223) 400400.

Call for Young Electronic Designers

The 1996 Young Electronic Designer of the Year Awards (YEDA) is inviting entries from students between the ages of 12 and 25. The key requirement of the competition is to design an electronic device that satisfies an everyday need.

Entries are judged on the originality of concept and design, technical competence and reliability, construction, presentation and finish. Marks are also given for commercial viability and everyday usefulness or for environmental and social awareness.

Regional judging takes place in February/March 1996, with the top six projects in each age category winning places in the national finals in April 1996, which are to be held at the London Science Museum. Entry forms are available from the YEDA Trust. The closing date for entries is 31 January 1995.

Contact: YEDA, Tel: (01403) 211048.

Combatting Computer Porn

The British Computing Society (BCS) has produced Guidance notes on combatting computer pornography, which outline practical steps that can be taken by employers, and parents.

Contact: BCS, Tel: (01793) 417417.

Laplink Modem Package

We have lost count of the number of modem manufacturers that have climbed into bed with an Internet provider to supply the consumer with a combined Internet ready-modem package. Hayes has taken a different tack. The company is bundling its OPTIMA 288 V.34 plus fax for PC Card with LapLink for Windows, from Travelling Software. This combined solution has an estimated street price of £240, saving the purchaser in the region of £158.

Contact: Hayes Microcomputer, Tel: (01252) 775555.

Digital Samples of Latest Alpha

Digital has began shipping samples of the world's fastest and highest-performance microprocessor, the Alpha 21164, manufactured in a 0·35µm process. Described at the Microprocessor Forum held in October in San Francisco, the new chip will achieve the highest SPEC92 and SPEC95 ratings of any microprocessor, either shipping or announced.

Contact: Digital, Tel: (01734) 868711.

Independent Radio Stations to Broadcast DAB

The Radio Authority has licensed its first Digital Audio Broadcasting (DAB) multiplex provider, National Telecommunications (NTL). The Authority has issued NTL with a restricted service license to simulcast, on analogue and DAB, an experimental showcase of Independent Radio stations in the Midlands.

Contact: Radio Authority, Tel: (0171) 430 2724.

CD ROM Shareware

The Public Domain Shareware Library (PDSL) has put an entire library of software on two CDs, titled *Libris Britannia*.

The first part CD ROM is called 'The Scientific and Technical Library CD ROM'. This CD contains items of interest to engineers, technicians and scientists. Subjects include electronics, artificial intelligence, communications, mathematics, technical drawing, security programming and ham radio.

The second part CD ROM is titled 'The Business Software Library', and contains 25 categories covering business and leisure programmes. The CD ROM set is priced £49.00, or the individual sections can be purchased for £29.00 each.

Contact: Public Domain Shareware Library, Tel: (01892) 663298.

Nintendo Tops a Billion

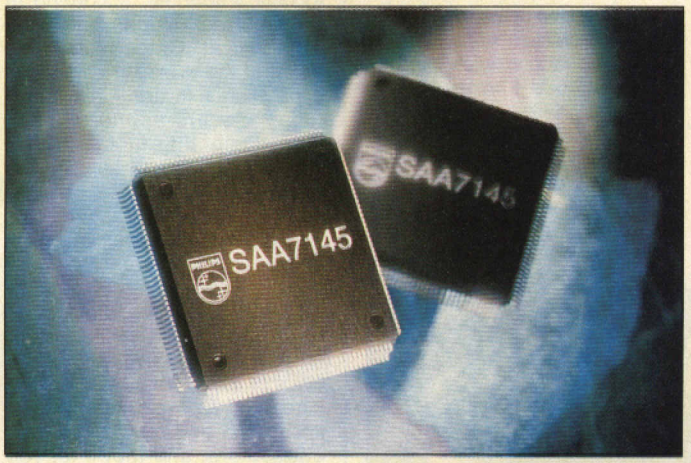
Since the introduction of the first Mario game in Japan in the early 80s, Nintendo has globally sold over a billion video games, at the rate of nearly three per second every minute of every day, for the past 12 years.

Contact: Nintendo, Tel: +1 206 882 2040.

Philips Semiconductors Multimedia PCI ICs

Philips Semiconductors has unveiled the first two members of a new family of Peripheral Interconnect (PCI) multimedia bridge ICs, the SAA7145 and the SAA7146. Both devices offer the capacity of building video and audio capture systems that include motion JPEG, MPEG, video conferencing and other multimedia applications. The PCI bus was introduced as a standard in 1994, after joint development work by a group of IC manufacturers headed by Intel. The standard addresses the requirements of multimedia and motion video interconnect hardware.

Contact: Philips Semiconductors, Tel: (+31) 40 72 20 91.



Former ICL Chairman Receives Electronics Gong

Within the same month that he announced his move to BT, Peter Bonfield, chairman and chief executive of ICL, was been awarded the 1995 Mountbatten Medal by the National Electronics Council (NEC). In recent years, Bonfield has played a leading role in restoring ICL to health and renewed confidence after a period of severe commercial setbacks. The current buoyant position of ICL owes a great deal to his tenacity, vision and leadership.

Contact: National Electronics Council, Tel: (0171) 240 1871.

Multi-featured Multimeter

Not content with measuring voltage and current, a new multimeter from Metrix Instruments can handle capacitance, sound levels and frequency. Costing £243, the MX55 hand-held device has a basic accuracy of 0·25%, and a 50,000 count resolution.

Contact: Metrix Instruments, Tel: (01256) 311877.

One in Four UK Small Businesses Still Without a PC

A research study of over 1,000 businesses conducted for Compaq in conjunction with the Co-operative Bank has revealed that one in four small businesses is still without a PC, although 60% of these companies say they will buy one within the next year. Nine out of ten of those companies which already have three or more PCs also plan to purchase within a year. Among those companies using PCs, the main business functions are for accounting or payroll, general correspondence and marketing, with only 8% reporting that they use their PCs for electronic communications.

For almost half of the small businesses surveyed, advice from colleagues and friends is still the most important source of information when selecting a PC, followed by past experience and PC magazine reviews. They also indicated that value for money in terms of price/performance is the most important factor in selecting a PC, followed closely by quality and reliability, and ease of use. Surprisingly, service and support were highly rated by only 25% of the respondents.

Contact: Compaq, Tel: (0181) 332 3000.

Gemplus License Electronic Tagging Concept

Smartcard manufacturer, Gemplus, has signed a licence agreement for BTG's Supertag technology. Under the agreement, Gemplus will manufacture and sell products incorporating Supertag technology. Supertag is an electronic tagging system based on a unique code encoded in a passive silicon tag. This electronic label concept enables up to 50 objects to be remotely scanned, identified and counted in less than a second, without the need to separate and scan items.

According to J. P. Gloton, CEO, Gemplus Electronics, "Supertag technology will form part of Gemplus' existing development programme, enabling the company to expand market penetration in RF applications. Gemplus has a unique combination of extensive expertise in silicon products and worldwide production capacity, and as part of this agreement, will provide Supertags and readers to other companies for a wide range of applications."

Contact: BTG, Tel: (0171) 403 6666.

Microscope Approaching the Atomic Level

Scientists at IBM's Thomas J. Watson Research Centre have created a new optical microscope capable of seeing objects 500 times smaller than previously possible with conventional optical microscopes. The microscope provides an unprecedented 1nm resolution, which is about five times larger than an individual atom, and has the potential to achieve a scientific first – imaging single atoms in visible light.

SIAM (Scanning Interferometric Apertureless Microscope) defies the current laws of imaging. It permits scientists to view images much smaller than the wavelength of light and approaching the atomic level, an achievement that has long been considered impossible, according to the basic principles of classical optics. The technique utilises sound waves as the analytical mechanism, as opposed to optics.

Contact: IBM, Tel: (0171) 202 3744.

The Electronic Key

Imagine a world where you only have one key. That key opens all doors around your house, immobilises your car, opens your garage, and disarms your home security system. And under this system, your key has a unique signature selected from over 200,000 combinations.

According to Electronic Research and Design, this technology exists today. The company has developed a system based on an passive silicon key and a decoder circuit. The technology is currently being used in commercial vehicle alarms and motorbike immobilisers, but has further applications in domestic security systems and electronic door applications.

Contact: Electronics Research & Design, Tel: (01923) 240525.

Silicon Clock

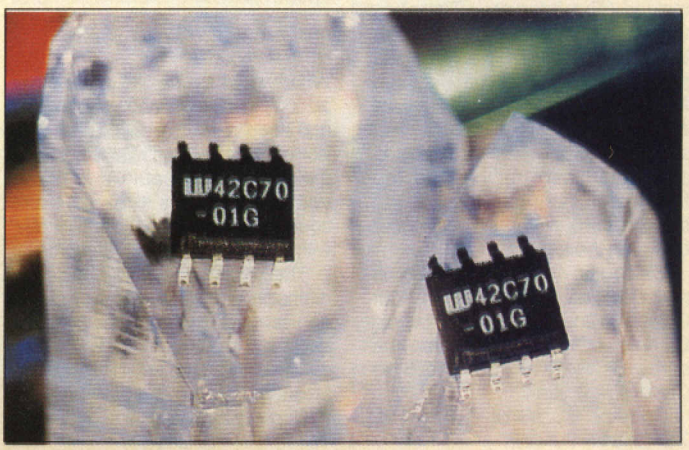
Microelectronics Technology has announced a clock generator designed to create an output clock which is a multiple of an input clock frequency, and synchronized to within a nanosecond.

The proprietary phase-locked loop technology is also useful for regenerating clock signals in high-speed systems, where duty cycles as poor as 20/80% can be fully restored to a typical level of 48/52% duty cycle.

The W42C70 is available in two versions, with an output frequency range from 10 to 120MHz, or from 2·5 to 30MHz. In a standard form, the devices feature two select pins which enable the user to select multiples or divisions of the input clock.

The standard versions of the W42C70 offer clock multiples of up to 16 times the input frequency, which enables lower speed clocks to be routed across PC boards, and then generate the required higher frequency locally with a good mark/space ratio.

Contact: Microeleronics Technology, Tel: (01844) 278781.



What's On?

The Christmas Computer Shopper Show 1995

Held at Grand Hall Olympia, London, 30th November to 3rd December. The show, which is the largest UK annual computer buying event was as good as usual. There were plenty of bargains for the PC computer consumer, with multimedia and computer upgrades at bargain prices.

For the first time in the UK a Virtual Reality headset manufactured by Victormaxx Technologies Inc. was available to UK buyers. Also demonstrated was Dr. Schueler's medical adviser UK: a CD-ROM that diagnoses symptoms as well as providing a wealth of information relating to health. Some of the latest games were also on display as were serious programmes for the PC user.

Show Report – Electronic Commerce

"Electronic Commerce is central to innovative management", claimed Ian Taylor, Minister for Science & Technology when he opened Electronic Commerce '95 last month. "Electronic Commerce takes many forms, and its use is growing dramatically as companies in all sectors recognise the benefits it offers. No-one can afford to ignore the impact of the new electronic ways of doing business."

Attendance at Electronic Commerce '95 bears this out, with over 3,000 delegates and visitors, plus more than 100 journalists, flocking to the conference and exhibition. The show was the launchpad for many new companies, products and services spanning a range of complementary technologies, including e-mail, EDI, multimedia and software, with the Internet much in evidence; World Wide Web sites were unveiled and major new contract wins were announced.

The successful use of Electronic Commerce by LACOTS (the local authorities co-ordinating body) to cut bureaucracy for environmental health and trading standards officers was recognised by the annual BT Award for Innovation in Electronic Commerce, presented by the Minister.

The lively debate which followed tackled 'The Internet – Threat or Opportunity for Electronic Commerce?' Under the chairmanship of respected journalist and industry commentator, Richard Sarson, the panel of eminent industry figures highlighted some of the key issues and concerns associated with trading over the Internet but concluded that, on balance, the opportunities significantly outweigh the threats.

Electronic Commerce '95 took place at The Barbican from 31st October to 2nd November; Electronic Commerce '96 will take place at the same venue from 29th to 31st October next year.

Contact: Electronic Commerce, Tel: (01344) 301022.

EMC Testing

In less than a month, it will become an offence to market or use equipment which does not meet electromagnetic compatibility (EMC) requirements. To give manufacturers an opportunity to check the development of the standards, the IEE held a one day briefing on 19th December. The meeting suggested that the best route to comply to the European Directive on EMC is through the application of standards. Compliance to the CE mark implies compliance with all relevant standards, placing responsibility in the hands of the manufacturer.

EMC regulations are covered in a series of three standards designated basic, generic, and product. The basic standards contain data on measurement techniques, operation requirements and instrumentation. Generics refer to environmental classifications, and contain limits of emissions and disturbance levels for immunity tests. The basic and generic standards can be used for equipment for which there is no product standard. That said, the product standards should eventually provide all the technical details to enable any apparatus to be checked for full compliance.

Contact: IEE, Tel: (0171) 240 1871.

Science Fiction – The Final Frontier

What would life be like on another planet? How do astronauts eat, breathe and sleep in space? Will Daleks ever learn to climb the stairs? This Christmas, the Science Museum is offering visitors the chance to examine the science facts behind the science fiction, with a new programme of events.

The programme, which includes drama performances, talks, workshops and story-telling, has been specially developed to complement the Star Trek exhibition, which is on at the Science Museum until the end of February.

Contact: The Science Museum, Tel: (0171) 938 8188.

Gates Look to the Future in Comdex/Fall Keynote

The personal computer industry is on the verge of a revolution that will bring dramatic changes to the way people work, by making software much more personalised and by providing easier access to online sources, according to Bill Gates, chairman and CEO of Microsoft. Gates shared his vision of the evolution of desktop application software – with which today's users spend most of their computing time – with a capacity audience at Comdex/Fall in Las Vegas.

"Today's newest technologies will help move applications to the next level: software that is not only easy to learn, but that actually adapts to the way people work, rather than making people learn to work as computers do. In the office of the future, personal computers will be even more flexible, accessible and responsive than ever before, and they'll let you work with people and information located anywhere, all from the comfortable familiarity of your computer desktop."

"Microsoft, together with allies in the computer industry, will do everything possible over the next few years to take advantage of new technologies including the Internet, voice recognition and natural language processing. We'll do this to help realise the greatest promise of the personalised, connected office; to make computing more relevant to the challenges of living, working and being productive in an increasingly complex world."

"Over the past two decades, we've moved from issuing non-intuitive commands to using productivity suites that can provide answers to natural-language questions. We'll see as much change in applications over the next five years as we saw in the last 20", Gates told attenders during his keynote address.

Adaptable software will learn from users rather than requiring them to learn from the software. Applications will analyse and adapt to users' work styles, anticipate commands and automate routine tasks. Users will be able to delegate repetitive or tedious jobs to software 'assistants' that will learn by example, and then work on command. For example, an 'assistant' could watch as the user works and automatically suggest an Internet search based on keywords it recognises in the document. These advances will decrease the need for training on the software.

Gates has to be admired for his success and vision, but there has to be a limit to the extent to which technology can influence our lives. Commenting on the explosion in communication in his book 'The Road Ahead' Gates said, "Many of us have struggled to stay in touch with people who are geographically distant. I used to date a woman who lived in a different city. We spent a lot of time together on e-mail and we figured out a way we could sort of go to the cinema together. We'd find a film playing in both places, drive to our respective theatres chatting on our cellular phones, then watch the movie, and on the way home we'd discuss it over the phone. In the future, this sort of virtual dating will be better because the film watching could be combined with a video-conference." Now, that is worrying.

Contact: Microsoft, Tel: +44 (0)1734 270001.

DIARY DATES

Every possible effort has been made to ensure that the information presented here is correct prior to publication. To avoid disappointment due to late changes or amendments, please contact event organisations to confirm details.

8 January. Winter Social, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

16 January. Annual General Meeting, Bury St. Edmunds Amateur Radio Society, Suffolk. Tel: (01284) 764804.

20 January to 25 March. Science Museum Superhighway UK Tour National Museum of Wales, Cardiff. Tel: (0171) 938 8192.

21 January. Oldham Amateur Radio Club Mobile Rally, Queen Elizabeth Hall, Civic Centre, West Street, Oldham, Lancs. Doors open 11am, 10.30 for disabled visitors. Event features the usual traders and a Bring and Buy Stall. Morse Tests available on demand. Talk-in on S22 via GB04RC, commencing 7.30am. Mobile Contact prize, up to 2pm. Regreshments and free Parking will be available. Tel: (01706) 846143 or (0161) 652 4164

22 January. Projects, grouses, problems and solutions, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

12 February. DX Cluster, John Clayton G4PDQ, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

26 February. Test Equipment Evening, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

11 March. Visit to The Cable & Wireless Company College, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

25 March. Surplus Equipment Sale, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

8 April. Annual General Meeting, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

22 April. The First Century of Sound Recording, Brian Hayward G8VXQ, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

23 to 25 April. The Institute of Physics Annual Conference, Telford International Centre, Telford. Tel: (0171) 235 6111.

13 May. Astronomy, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257.

27 May. Open Evening, Stratford-upon-Avon and District Radio Society, Stratford-upon-Avon. Tel: (01789) 295257

Please send details of events for inclusion in 'Diary Dates' to: News Editor, *Electronics – The Maplin Magazine*, P.O. Box 3, Rayleigh, Essex SS6 8LR.

A readers' forum for your views and comments. If you would like to contribute, please address your replies to:

The Editor, **Electronics – The Maplin Magazine**
***P.O. Box 3, Rayleigh, Essex SS6 8LR, or send an e-mail to:* AYV@maplin.demon.co.uk**

Dear Editor

AIR YOUR VIEWS

Maplin On Internet 1

Dear Sir,
Do Maplin have any plans for ordering goods via the Internet – once Netscape get their new secure Web Browser released, that is? I would find it easier to place orders than sending a fax, which I do at present, and you could load the order directly onto your computer. The system could also advise of out-of-stock items, invalid order codes and such; similar to your CashTel. You could also have a link to new product lines, etc.
In case you're wondering, the reason I don't use CashTel is that I live on mainland Europe, and the 'phone call costs are prohibitive.
Brian Edwards,
100023.1075@CompuServe.

Maplin On Internet 2

Dear Editor,
Have you got a home page on the Internet yet?
Brian.mchattie@ayo.

Maplin On Internet 3

Dear Sir,
I suggest that Maplin set up a home-page on the Internet/World Wide Web. Ordering and checking for components or kits will be very much easier and cheaper, especially for overseas customers. CashTel can be very costly, since the telephone rate for overseas calls can sometimes cost more than the order itself! The Millennium 4-20 Valve Amplifier has received very positive reviews by popular Hi-Fi magazines. However, the amplifier is based on the ultralinear push-pull technology. Serious audiophiles prefer the single-ended valve amplifier design for its detailed and sweet sound. I hope that Maplin's engineers start designing a single-ended valve amplifier and produce a kit soon.
Azman Ithnin, Johore, Malaysia.

Maplin On Internet 4

Dear Editor,
I have been reading *Electronics* since the first issue, and I am very pleased with the coverage you are giving the Internet, both in terms of articles and site surveys. However, I feel that you are missing a very important site, and that is one for yourselves at Maplin. You have had for a long time, the facilities for customers to use computers and modems to order components, and the magazine covers the use of computers in communications, so I feel that an expansion onto the Internet is a logical and necessary way forward for Maplin to expand. A virtual catalogue and copies of your magazine would make an interesting WWW site, with the possibility of on-line ordering via secure communications. Customers could preregister their payment and address details with you by post or phone, and then place orders over the Internet or by e-mail, with a customer or registration number similar to schemes operated by certain other companies. Looking forward to seeing news of a Maplin site in a forthcoming site survey!
Geraint Williams, geraint@hyge.demon.

The subject of Maplin having a site on the Internet has become something of a frequently-asked question (FAQ) in recent months, and this would indeed open up useful possibilities such as the displaying of Magazine and Catalogue pages, and convenient ordering facilities. Maplin are looking closely into having a server on the Web, which would allow full ordering, e-mail and WWW presence. Test pages have been made up by the Internet-enthusiast editor of Electronics as a step towards achieving this goal, which is a distinct possibility for 1996. We will bring you news of any developments regarding the launching of a Maplin site, as soon as they happen! The project suggestion for a single-ended valve Hi-Fi amplifier has been noted as an idea for a future project.

STAR LETTER

In this issue, R. H. M. Quade of Heywood in Lancashire wins the Star Letter Award of a Maplin £5 Gift Token, for his suggested method of sharpening up the Video Box image.

★★★★★★★★★★★★★★★★★★★★

Dear Sir,
Another Video Box modification!
A detail or sharpness control can be added to the Video Box (see *Electronics* Issue 51, page 64 – Ed.) very simply – refer to the included circuit diagram shown in Figure 1. The modification is based around TR9 and has both 'sharp' and 'soft' functions. A 1kΩ linear potentiometer is used, and the slider is connected to the positive supply end of either R30 or R25. A 1n5F polystyrene capacitor is wired to the minimum (soft) end of the 1kΩ potentiometer and R25 at the base of TR9. The maximum (or sharp) end of the potentiometer is connected to an 820pF polystyrene capacitor and the emitter of TR9 via a 100Ω limiting resistor – this can be connected to the emitter end of R30. This should now provide a sharpness boost at maximum and a softer picture at the minimum end. Wires can be connected to the ends of R30 and R25 from the top of the circuit board. This control is useful when editing from a camcorder or copying video cassettes.

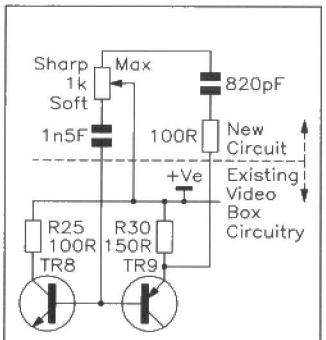


Figure 1.

Thank you for sharing this useful and very worthwhile addition to the Video Box circuit. Refer also to Electronics *Issue 57 (September 1992 edition), page 21, for details of another modification to further improve the operation of this popular project.*

★★★★★★★★★★★★★★★★★★★★

CompuServe Correction

Dear Editor,
Many thanks for an interesting magazine and more information on the Internet. Unfortunately, the section on CompuServe pricing in The Internet Part 2 (issue 97) was not correct. For several months now, there has been 5 FREE hours use of extended services a month, which was not mentioned.
James Pring,
100272.1511@CompuServe.

Thank you for your comments and for informing us of the omission in the Internet article regarding Compuserve's pricing policy.

A Tinny Response to Point Contact

Dear Sir,
PC's cry for a 'plain tin-plate' moved me quietly, as I don't like to hear of a deprived laboratory or workshop! We opened a tin of John West's grapefruit this morning, and lo, it's a plain tin! I'm always interested in PC's comments, but I'm really a valve (not tube) man, going back to Williamson and beyond. My first radio and amplifier were Def and 2LF – before your time.
Ralph Beddis, Saltdean, Brighton.

Belgian Biccies

Dear Editor,
PC was bemoaning the dearth of flat tin-plate in the culinary industry. Might I suggest biscuit tins, available from various purveyors of fine Belgian biscuits. Only the lid is covered by the makers name, but the rest of the box is completely unsullied by corrugations and such. Put a couple of boxes on the coffee table at Christmas, and hey presto, by New Year you have several square feet of usable tin-plate.
Brian Edwards,
100023.1075@CompuServe

Many thanks to the numerous folk who contacted us in response to PC's plea for sources of useable tin-plate – see also Stray Signals on page 54 of this issue, for further updates on the tin-plate situation!

Roll On the Sequencer!

Dear Sir,
I have recently bought one of your Multi-Strobe kits (Order Code LT90X). While I have been extremely pleased with its performance and specification, I must say that I am now a little disappointed that as yet, there is no information as to how the RS-232 interface (Multi-Strobe Sequencer – Ed.) works. The interface in question is possibly the most useful part of the unit, as many professional strobe lights do not even consider providing this connection facility.
I have been expecting the second part of the article on this unit to appear in *Electronics* for some time now, but there is still no sign of the article being published. Unfortunately for me, time is now running out. I need to be able to interface the strobe unit to a computer within the next few weeks, as I intend to use the unit as part of a theatre production. I would be pleased if you could tell me any information concerning the RS-232 interface, and when the article in question will be published in the magazine.
Patrick Keys, Reading, Berkshire.

We apologise profusely for the delay in bringing the second part of the Multi-Strobe (Sequencer) project to these pages, which has been largely due to the very considerable amount of development work that has been required for what will be a quite sophisticated design, necessary for the impressive features that the system will offer. However, as the saying goes, good things come to those who wait! In fact, the Multi-Strobe Sequencer project is scheduled to appear in the hundredth edition of Electronics *(the April 1996 issue), along with many other exciting projects and features to celebrate this milestone event in the history of the magazine.*

Interfacing Update: Take Three

In response to the final letter in issue 95 from Ken Hughes, the Centronics serial interface for the Amstrad PCW8000 is part number CPS8256. The Centronics port address is E9 (hexadecimal). For possible sources of this interface, see the Amstrad PCW Plus magazine, or try contacting the PCW Users Group, last known of at: 100 St Peters Close, Morton-on-Lugg, Hereford, HR4 8DW, Tel: (01432) 761861. Alternatively, try Suredata, Unit 5, Stanley House, Stanley Avenue, Wembley, Middlesex HA0 4JB, Tel: (0181) 902 5218.
G. L. Manning, Edgware, Middlesex.

Thank you for providing this information to further add to the sources of Centronics interfaces suitable for the Amstrad PCW8256 that were published in last month's Air Your Views.

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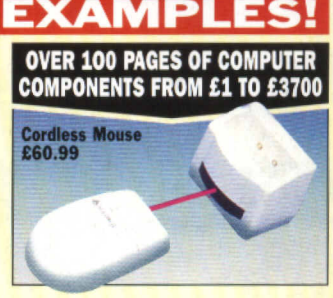

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Catalogue available in Southern Africa from CNA or direct from Maplin SA (024) 515124. R39,95 (inc p&p).